GAO General Accounting Office
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Comptroller General
of the United States

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To the President of the Senate and the
Speaker of the House of Representatives

As you know, the Congress has been deliberating landmark telecommunications legislation. At the same time, the administration views recent technological advances in telecommunications as an opportunity to build an Information Superhighway that will place voice, data, and video information at consumers' fingertips. Increased competition in telecommunications could spur private investors to build the superhighway, but existing telecommunications legislation and court orders limit or prohibit certain types of telecommunications competition.

This report provides an overview of several major issues facing the Congress as it considers the telecommunications legislation. We discuss (1) managing the transition to a more competitive local telecommunications marketplace; (2) ensuring universal service in a competitive marketplace; and (3) ensuring network security, privacy, reliability, and interoperability.

We are sending copies of this report to all Members of Congress; the Chairman, Federal Communications Commission; and the Assistant Secretary of Commerce for Communications and Information. We will also make copies available to others on request.

This report was prepared under the direction of Kenneth M. Mead, Director, Transportation and Telecommunications Issues, who may be reached on (202) 512-2834. Other major contributors to this report are listed in appendix IV.

Kent O. Fullberg for

Charles A. Bowsher
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A-1

Purpose

Technological advances in the transmission of voice, video, and data are fostering fundamental changes in the telecommunications industry. For example, large local telephone companies plan to offer video services in competition with cable and broadcast television, while cable television companies plan to offer local telephone service over their wires in competition with the local telephone companies. The administration believes that these technological changes provide the opportunity to develop an "Information Superhighway" that could provide every element of society with ready access to data, voice, and video communications. Concurrently, the Congress is considering sweeping changes to telecommunications regulations to keep pace with this dynamic industry. GAO prepared this report to serve as an overview of three key issues that decisionmakers may face as they deliberate telecommunications legislation; it focuses on three pivotal issues they face in formulating new telecommunications legislation: (1) managing the transition to a more competitive local telecommunications marketplace; (2) ensuring that all consumers have access to affordable telecommunications as competition develops; and (3) ensuring that the Information Superhighway provides adequate security, privacy, reliability, and interoperability.

Background

The administration has set forth its vision of a National Information Infrastructure, commonly known as the Information Superhighway, which could fundamentally change the way we live, work, and play. As easily as turning on a television, school children could obtain access to instructional programming from distant learning centers, or a doctor in a remote area could transmit X-rays or test results to experts for consultation. Television viewers may be able to interactively order movies or other recorded programs and be able to pause, fast-forward, or reverse them. While these services are currently available on a limited scale, the Information Superhighway could make them a routine part of everyday life. Advances in digital technology allow these services to be provided through telephone or cable television companies or through some other providers, such as wireless telephone or satellite television services, thus blurring the formerly distinct lines among industry segments.

Results in Brief

Competition in the long-distance telephone market, facilitated by technological advances and regulatory changes, has led to large investments in the long-distance infrastructure; these investments have provided the capacity likely to be required to support the interstate portion of the Information Superhighway. Similar increases in the local

infrastructure's capacity are needed to allow the superhighway's services to reach homes, businesses, and schools. However, because the local infrastructure is larger and more widely distributed than the long-distance infrastructure, these upgrades will be more costly. Some upgrades have occurred through further technological advances and emerging competition at the local level. However, the extent to which competition can develop in the local marketplace is limited by the provisions of the 1982 consent decree that broke up the American Telephone and Telegraph Company, certain provisions of the 1984 Cable Communications Policy Act, and certain state laws. Industry leaders, the Congress, and the administration agree in principle that increased competition will accelerate investment in the local infrastructure, and the Congress is developing legislation to that end. However, much debate has focused on how to protect consumers from anticompetitive behavior if it occurs during the transition to increased competition. The prospect of increased competition in certain segments of the local telephone service market raises questions about how to ensure continued access to affordable telephone service for all consumers—commonly known as universal service. Regulators have developed a cost allocation and recovery system that results in above-cost rates for some services and below-cost rates for residential and rural services. However, as competition becomes more widespread, local telephone companies could lose to competitors the revenues from services now priced above costs. Since these revenues help provide affordable telephone service for residential and rural subscribers, an alternate source of funding will be required. Also, as the array of available services expands, questions arise about which services should be provided to everyone at affordable rates and which, if any, should be universally available as options.

If the Information Superhighway is to function as envisioned, a number of technical challenges need attention. The security and privacy of personal, medical, financial, and proprietary data must be safeguarded. The network's interoperability and reliability must be ensured to protect against system failures. Number portability—the capability of allowing consumers to switch telecommunications providers without changing telephone numbers—will be critical to facilitating competition. Because no single entity will build the Information Superhighway, no single entity is in a position to resolve these challenges in a coordinated fashion.

Principal Findings

Managing the Transition to a More Competitive Local Telecommunications Marketplace Presents Challenges

After the American Telephone and Telegraph Company was broken up in 1984, its share of long-distance revenues dropped from 92 percent to below 60 percent in 1993. The increased competition and technological advances have led to vast improvements in the long-distance infrastructure. Further advances in technology are making competition more feasible in the local market, and in some areas competitors have won customers from the local telephone companies.

Federal government and industry officials believe that increased competition in local telephone and cable television markets will be a key factor in increasing choices and lowering prices and in encouraging the private sector to invest in the local capacity improvements that are necessary to make the Information Superhighway a reality. However, a number of states have laws prohibiting competition for local telephone service. Furthermore, the 1984 Cable Communications Policy Act prohibits local telephone companies from providing video services in their own service areas. The Congress has been considering bills that would, among other things, facilitate competition by permitting Bell operating companies—the local telephone companies spun off from the American Telephone and Telegraph Company in 1984—to enter additional markets and allow the Bells and other local telephone companies to provide video services in their own service areas. The bills would also supersede state laws that now prohibit local telephone competition.

However, the bills propose different criteria for allowing the Bell operating companies to compete in related markets, reflecting controversy over whether the conditions that led to the restrictions—particularly the Bells' dominant market power—have changed sufficiently to permit the Bells to enter additional markets. A key concern has been that without sufficient local competition, the Bells' market power could allow them to inhibit competition in markets that they enter.

Universal Service Funding Process and Definition Need Revision

Increased competition in the local market raises questions about how to continue to pursue the objectives of universal service. Many observers believe that regulators have generally required telephone companies to allocate certain costs of the local telephone infrastructure to other services, leading the local telephone companies to charge above-cost rates

for long-distance companies' access to the local infrastructure and for intrastate long-distance service. Local residential and rural telephone service is believed by many to be provided at below-cost rates. However, as competitors attract customers by offering lower rates on certain services, the local telephone companies stand to lose the funds that have heretofore allowed them to keep residential rates at affordable levels. The local companies say that raising rates to cover costs could place a financial strain on some subscribers, thereby jeopardizing universal service. Rather than relying on the local telephone companies to provide affordable service, some other mechanism will be needed in a competitive environment.

Universal service has traditionally included only rudimentary telephone service—not the currently available advanced options such as caller identification and call waiting. Through the Information Superhighway, many additional services, such as on-line access to health care or government information, could become available, raising the question of which, if any, additional services should be universally available. Building the infrastructure to provide all these services could cost up to $500 billion, according to some estimates. Redefining universal service in the future presents challenges in balancing the benefits of, expected demand for, and cost of these services to consumers.

Information Superhighway Poses Technical Challenges

Security, privacy, and reliability will be important issues as the Information Superhighway develops. Computer programs have been developed that can undermine many computer security systems and provide access to vast amounts of personal or proprietary information. Meanwhile, law enforcement agencies face advanced software coding schemes that can foil decoding efforts and telecommunications equipment that can be made immune to wiretapping. System reliability is important to avoid a widespread shutdown of telecommunications links such as occurred in the Northeast in 1991, disabling the air traffic control system and stalling commercial activity.

Standards have not been established to ensure the interoperability of new communications technologies. For example, interoperability problems have surfaced in videoconferencing equipment made by different companies and in digital networks developed by various telephone companies. Additionally, standards need to be developed for data bases that would allow subscribers to change telephone companies without changing telephone numbers. Addressing these challenges raises the

question of who will provide the systemwide perspective to encourage the industry to develop a secure, reliable, smoothly functioning infrastructure.

Recommendations

Because this report is intended to serve as an overview of key telecommunications issues, it makes no recommendations.

Agency Comments

GAO informally discussed information in this report with the Deputy Chief Counsel of the National Telecommunications and Information Administration, Department of Commerce; and the acting Chief, Common Carrier Bureau, and the Chief, Office of Plans and Policy, Federal Communications Commission. While agreeing generally with the report's contents, officials of both agencies encouraged GAO to distinguish more clearly between the Bell operating companies and other local telephone companies and suggested other points of clarification. National Telecommunications and Information Administration officials urged GAO to clarify the respective regulatory roles of state and federal agencies and to mention intellectual property rights as an Information Superhighway issue. Federal Communications Commission officials suggested that GAO provide additional background information on the American Telephone and Telegraph Company consent decree and on the sources of universal service funding.

In response, GAO (1) revised the draft to more clearly reflect that local telephone companies provide most local telephone service and that the Bell operating companies are specific local telephone companies that are subject to the American Telephone and Telegraph Company consent decree; (2) added information on the roles of the states in regulating local telephone rates and acknowledged intellectual property rights as an issue; and (3) provided additional background on the American Telephone and Telegraph Company consent decree and revised the discussion of universal service. GAO incorporated other comments, where appropriate, throughout the report.

Contents

Abbreviations

ATM	asynchronous transfer mode
AT&T	American Telephone and Telegraph Company
BOC	Bell operating company
CAP	competitive access provider
FCC	Federal Communications Commission
IBM	International Business Machines
ISDN	Integrated Services Digital Network
LAN	local area network
PCS	personal communications service

Introduction

The term "National Information Infrastructure"—commonly known as the "Information Superhighway"[1]—refers collectively to the hardware, software, standards, personnel, and training facilities that will one day form an information infrastructure that will place vast quantities of voice, video, and data at users' fingertips. Delivery of these services is being made possible by advances in digital communications, which allow voice, video, and data to travel together over any type of telecommunications medium. These developments are unfolding against a financial and regulatory backdrop that limits the expansion plans of major segments of the telecommunications industry. Recognizing that the regulatory structure of the telecommunications industry needs updating, lawmakers are considering sweeping changes designed to provide a framework that will promote competition and innovation while protecting consumers over the coming decades.

Telecommunications Encompasses Many Technologies

Telecommunications, which we define as voice, video, or data (textual information) transmission, travels over a variety of wired and wireless networks.[2] Telephone networks carry primarily voice conversations over a combination of copper wire and fiber-optic cable, connecting the caller and receiver through a system of switches. Cellular telephone networks use a combination of wired and wireless technology to connect the caller with the receiver. Television and radio stations send their signals through the airwaves over broadcast networks, while cable television signals reach the television set through a wired network. Data normally travel between computers over telephone wires. On the horizon are developing technologies that could add networks for satellite television and wireless personal communications services (PCS) that could allow anyone, anywhere, to send and receive voice, video, and data.

The Information Superhighway Would Integrate Technologies Into a Seamless Web

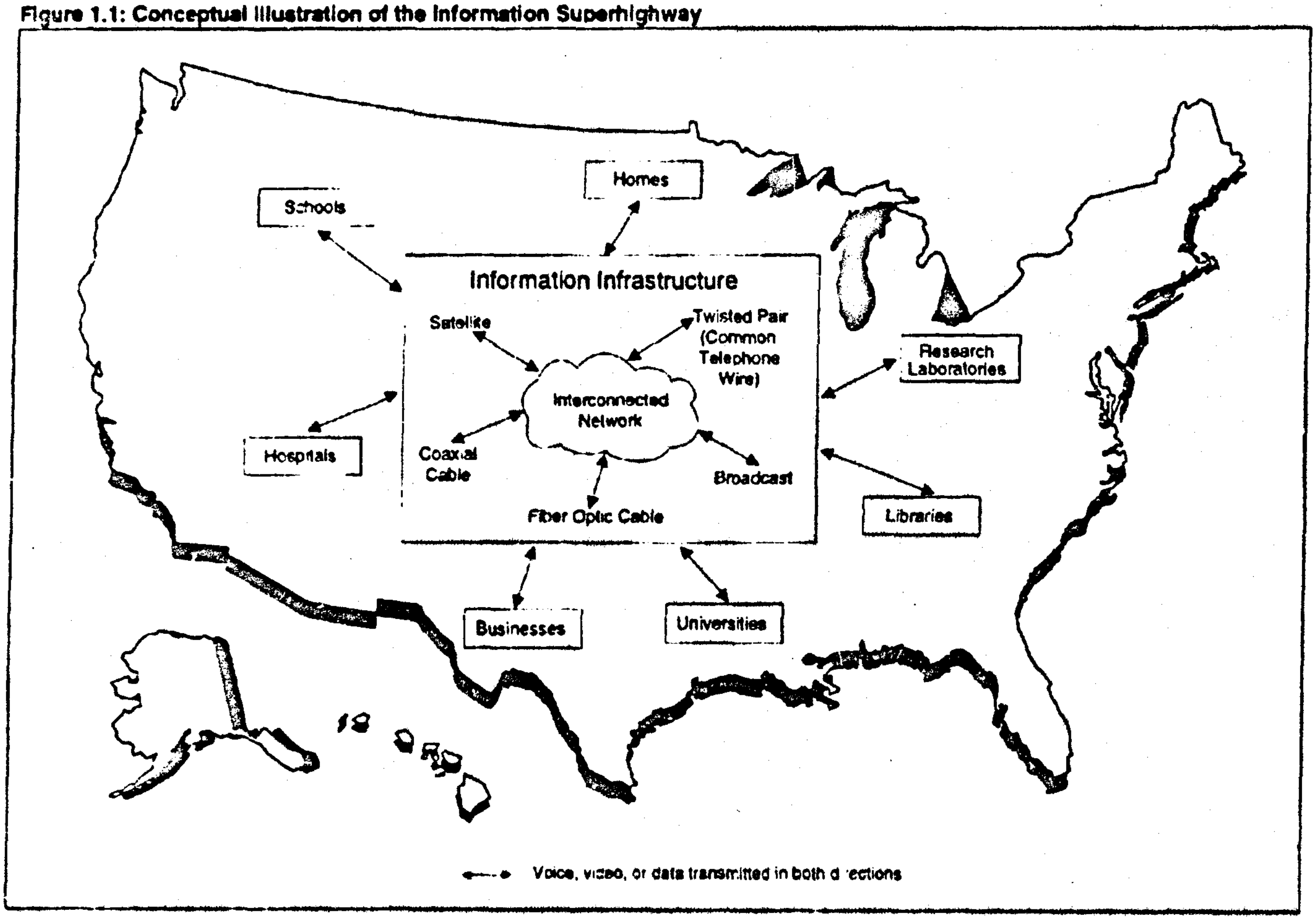
The concept of the Information Superhighway integrates these individual telecommunications networks into a seamless web that would allow information to travel over wires, be transferred to an over-the-air network, and be transferred among networks as it moves from sender to receiver. The administration believes that the Information Superhighway could unleash an "information revolution" that would change forever the way people live, work, and interact with each other. Figure 1.1 illustrates

[1]The administration has used the terms "National Information Infrastructure" and "Information Superhighway" synonymously.

[2]A network is a group of interconnected communications facilities and devices used to transmit information.

conceptually how the Information Superhighway might function. The superhighway could, for example, expand opportunities for students in rural or inner-city schools to have access to top-level instructional programming transmitted from distant learning centers. Rural doctors could transmit X-rays or test results to experts at leading medical centers. Businesses could more easily connect with customers and suppliers, improve communications among employees, and gather competitive data. Finally, individuals could enjoy more work/home flexibility by telecommuting—working from home while maintaining contact with the office through telephone, fax, and personal computer.

Figure 1.1: Conceptual Illustration of the Information Superhighway



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The Information Superhighway could also affect life in the home. Through interactive television, viewers would no longer be subject to programming schedules. Instead, they could select a previously recorded program—such as a movie, news report, or sporting event—and view it on their televisions. In addition, they could pause, reverse, or fast-forward the program, as they can today in viewing video tapes. Using the Information Superhighway, consumers could electronically select merchandise now available through mail-order catalogs. While many of these services are currently available on a limited scale, all of them could become a routine part of everyday life through the Information Superhighway.

Although no one now knows exactly how the superhighway will evolve, the Internet provides current-day examples of the types of services that the Information Superhighway could provide. The Internet began about 25 years ago as a federal effort to investigate computer networking technology under the Advanced Research Projects Agency of the Department of Defense. Today, the Internet connects users to a network of networks that spans all parts of the United States and other sites around the world, and it supports activities in the federal government, universities, and industry research laboratories. The core of the Internet operates over federal "backbone" networks, including those of the National Science Foundation, the National Aeronautics and Space Administration, the Department of Energy, and the Department of Defense. Most users obtain access to the Internet backbone through numerous other networks that, collectively, form the Internet.

Digitization Makes It All Possible

Digitization makes telecommunications signals interchangeable, thus allowing signals from different sources to travel over various types of infrastructure. Digitization translates voice, data, and video signals into the common language of computers—"ones" and "zeros" called "bits." This process greatly increases flexibility in determining whether the signals must be sent over a specific type of infrastructure. Through digitization, the Information Superhighway can carry any type of "freight" in the form of bits—be they voice, video, or data—from the source to the user.

Increases in Infrastructure Capacity Are Required

In order to carry interactive video services, some portions of the telecommunications infrastructure require greater capacity. High-capacity "broadband" fiber-optic cable, which could carry many Information Superhighway services, exists in the interstate, long-distance portion of

the infrastructure.[3] However, the local infrastructure, largely consisting of copper telephone wire and coaxial cable television wire, has lower capacity. While copper telephone wire enters about 95 percent of U.S. residences and businesses and provides interactive, two-way communications, its low capacity would prevent some Information Superhighway services (e.g., interactive video) from reaching users in many homes, schools, libraries, or medical centers. Coaxial cable, which is used for cable television, is available to about 95 percent, and enters about 60 percent, of U.S. residences. It has about 900 times the capacity of copper wire. Although the capacity of coaxial cable is not as great as that of fiber-optic cable, coaxial cable could meet most of the currently envisioned residential requirements for Information Superhighway services. However, to carry interactive two-way traffic, the cable infrastructure's delivery systems must be upgraded. According to an industry trade association, such upgrades would cost about $20 billion.

Existing Legal and Regulatory Structure Sets the Stage for Potential Changes

The Communications Act of 1934 established the Federal Communications Commission (FCC) as an independent agency

> "for the purpose of regulating interstate and foreign commerce in communication by wire and radio so as to make available, so far as possible, to all the people of the United States a rapid, efficient, nationwide and worldwide wire and radio communications service with adequate facilities at reasonable charges."

As enacted, the act focused on telephone and radio, but it was not restricted to any particular technology. The act now covers many new technologies such as cable television, cellular telephones, and satellite communications. The act generally left regulation of intrastate services to the states. Appendix II provides information on the other agencies that establish or influence telecommunications policy and the diverse set of businesses that make up the telecommunications industry.

Following the passage of the Communications Act of 1934, the American Telephone and Telegraph Company (AT&T) continued to operate as a regulated monopoly but generally remained subject to federal antitrust laws. Throughout the 1950s and 1960s, competitive pressures mounted from innovations in customer premises equipment (e.g., telephones) and improvements in radio technology. FCC responded with a number of regulatory decisions that allowed limited competition in specific markets. In 1974, the United States issued the third of three major antitrust actions

[3] For additional information on capacity and other aspects of telecommunications technology, see appendix I. This report also contains a glossary of telecommunications terms.

against AT&T, each of which ended in a settlement agreement. The 1974 action was settled in 1982 through a consent decree that was approved with modifications by the court.

The 1982 consent decree significantly changed the regulatory landscape of the telecommunications industry by generally separating the competitive segments of the telephone industry—long-distance service and customer premises equipment—from what was viewed as a natural monopoly[4] —local telephone service. The decree divested AT&T of its 22 local telephone service companies, called Bell operating companies (BOCs).

Today the BOCs, together with GTE, a holding company for 24 local telephone companies, and nearly 1,300 other local telephone companies provide local telephone service.[5] AT&T continues to provide long-distance service in competition with other long-distance carriers. Unlike the days before divestiture when a single company provided a majority of service, long-distance calls now travel over competitive long-distance carriers' lines for the long-distance portion of the call, and through the local telephone company's infrastructure at the call's beginning and end points. The consent decree required that the BOCs grant long-distance carriers access to their local infrastructure to complete long-distance connections, while FCC regulations imposed similar requirements on other local telephone companies. The local telephone companies charge the long-distance companies access fees to route long-distance calls through the local telephone lines.

Industry Is Converging, Providing Competitive Opportunities

Against this legal and regulatory backdrop, the telecommunications industry is undergoing substantial change. The emerging ability to transmit data, voice, and video through a variety of methods is stimulating formerly separate segments of the industry to diversify product lines and to take advantage of complementary strengths. For example, some large telephone companies see opportunities to compete in their existing service areas with cable and broadcast television companies by

[4]A natural monopoly exists when the costs of production decline as additional output is produced so that a single producer can supply the entire market cheaper than any combination of two or more producers.

[5]AT&T's consent decree does not apply to GTE or to other local telephone companies. However, in the early 1980s, the government filed an antitrust action against GTE challenging GTE's acquisition of the telecommunication enterprises of Southern Pacific Corp. (which operated Sprint long-distance service). Under a court-approved consent decree, the acquisition was permitted subject to a number of conditions, including that GTE's local monopoly operations be kept separate from its long-distance and other competitive operations. In 1993, GTE was the second largest telephone company in terms of revenue and fourth in terms of access lines.

transmitting or providing video programming over telephone lines, while cable television companies are considering providing local telephone service over their infrastructure, in competition with the telephone companies.

To optimally position themselves to provide diversified services, these formerly separate segments of the telecommunications industry are considering mergers and strategic alliances. Cable companies believe that the large telephone companies' substantial cash flows will help them upgrade their systems to provide telephone service, while the telephone companies believe that the cable companies' experience in managing and marketing video services will be a critical asset to compete successfully in the video programming market. Additionally, the large telephone companies and long-distance companies are acquiring or investing in cellular telephone companies to broaden their networks and take advantage of advances in wireless technology.

Some such mergers have already occurred. Southwestern Bell has purchased a cable system in Montgomery County, Maryland, through which it plans to begin offering local telephone services. Sprint, a long-distance provider, merged with Centel Cellular company, which at the time of the merger was the nation's ninth largest cellular provider.

Legislative Changes Have Been Proposed

Lawmakers are considering legislation designed to allow increased competition in the telecommunications industry. The proposed legislation addresses several major issues, such as whether federal legislation should supersede state laws that prohibit local telephone competition; whether and under what conditions the BOCs should be allowed entry into long-distance telephone service; whether and under what conditions local telephone companies, including the BOCs, should be allowed to provide video services in their service areas; how to ensure competitors' equal access to local, long-distance, and cellular infrastructures; and how to ensure that no consumers lose access to telecommunications services because of rate increases. In addition, the legislation would shift much of the locus of responsibility for overseeing BOCs' entry into certain competitive markets from the courts, where it has resided since 1984, to the executive branch of the federal government.

Decision Makers Face Several Issues

The prospect of a restructured telecommunications industry that would collectively build and operate an Information Superhighway raises a

number of issues. Chapter 2 discusses the central issues related to reducing barriers to local telecommunications competition. Chapter 3 discusses the issues associated with providing universal service in a competitive environment, and chapter 4 provides an overview of some of the pressing technical challenges that decision makers will face as the Information Superhighway develops.

Objectives, Scope, and Methodology

Under our basic legislative responsibility to prepare evaluations of issues that the Comptroller General believes will assist the Congress, we reviewed issues facing decision makers as they develop new telecommunications laws and regulations to facilitate the development of the Information Superhighway. These issues include (1) managing the transition to a more competitive local telecommunications marketplace; (2) ensuring that all consumers have access to affordable telecommunications as competition develops; and (3) ensuring that the Information Superhighway provides adequate security, privacy, reliability and interoperability.

To determine the central issues facing decision makers, we reviewed an extensive body of reports, white papers, and industry statements. We held discussions with officials at FCC, the Department of Commerce (the National Institute of Standards and Technology and the National Telecommunications and Information Administration), the National Science Foundation, the Department of Education, the Office of Technology Assessment, the Department of Defense, the National Security Agency, and the Rural Electrification Administration. We also met with representatives of a long-distance carrier and of the United States Telephone Association. To keep abreast of legislative developments, we closely followed the numerous congressional hearings on telecommunications issues held during 1993 and 1994. We conducted our work between October 1993 and August 1994.

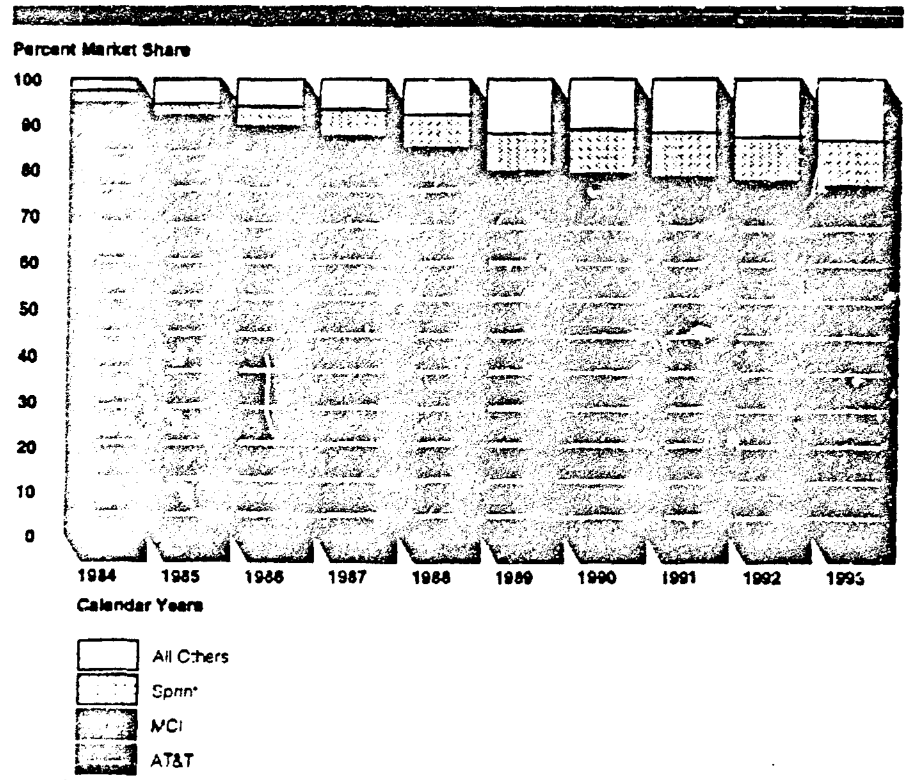
Reducing Barriers to Local Competition May Help Build the Information Superhighway, but Presents Challenges

Technological advances and competition in the long-distance market have led to infrastructure improvements needed to support the interstate portion of the Information Superhighway. However, the local infrastructure needs significant improvement to bring the superhighway to homes, businesses, and schools. Local infrastructure improvements have begun, stimulated in part by the limited competition that has begun to emerge in local telephone services. However, legal and regulatory barriers, established to maintain affordable residential telephone rates and protect consumers from the local telephone company's monopoly power, limit the extent to which competition can develop at the local level. Consequently, the Congress is considering regulatory revisions aimed at removing barriers to transforming the local market from one dominated by the local telephone company to one that is more competitive while retaining appropriate safeguards. However, disagreement exists over whether and to what extent consumers will need protection from the local telephone company's market power.

Technological Advances and Competition Led to Improvements in the Long-Distance Infrastructure

The divestiture of AT&T, which became effective in 1984, helped facilitate the growth of competition in the long-distance telephone service market. Spurred by advances in technology, some competitors had been attempting to establish a competitive foothold in the long-distance market since FCC first authorized competitive entry in 1969. However, at the time of divestiture, AT&T held 92 percent of total long-distance revenues. As figure 2.1 shows, AT&T's market share steadily decreased after 1984 but remained well over 50 percent in 1993.

Figure 2.1: Percentage of Long-Distance Revenues of AT&T, MCI, Sprint, and All Other Long-Distance Carriers, 1984-93

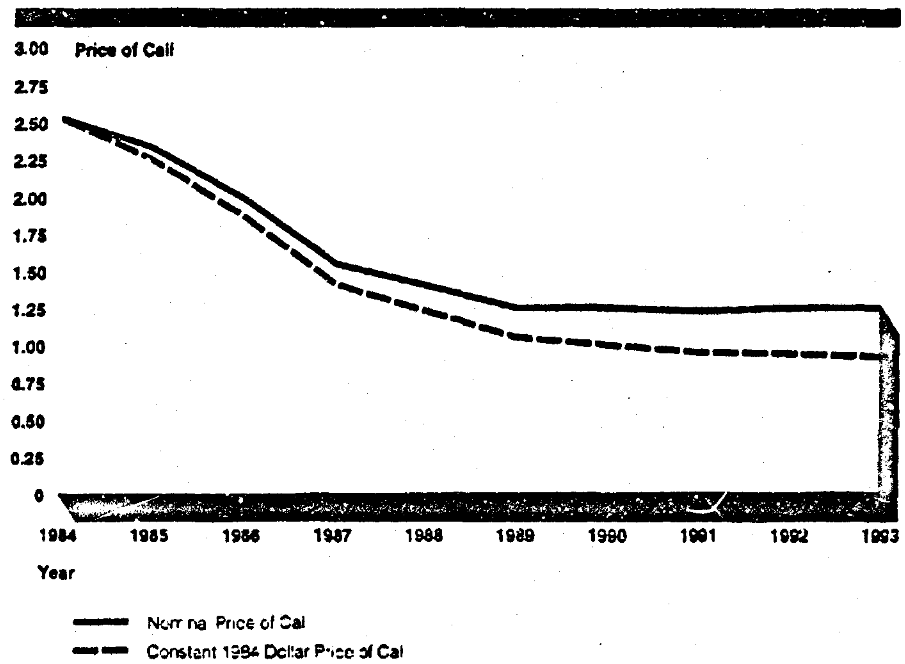


The consent decree, together with FCC requirements that local telephone companies provide every long-distance competitor equal access to the local infrastructure, enhanced the ability of new long-distance companies to compete with AT&T. While other long distance providers—MCI, Sprint, and AT&T—hold most of the long-distance market, FCC estimated that about 400 long-distance carriers were in business as of January 1994, allowing customers to choose among a wide range of services, pricing arrangements, and service options. Because of its significant market share, AT&T has remained subject to FCC's regulatory oversight for long-distance services.

Since the divestiture, consumers have benefited from lower prices and the long-distance infrastructure has been significantly upgraded. As figure 2.2 shows, published tariff rates declined sharply between 1984 and 1989 and

more slowly since then,[6] while long-distance usage has increased, as figure 2.3 shows.

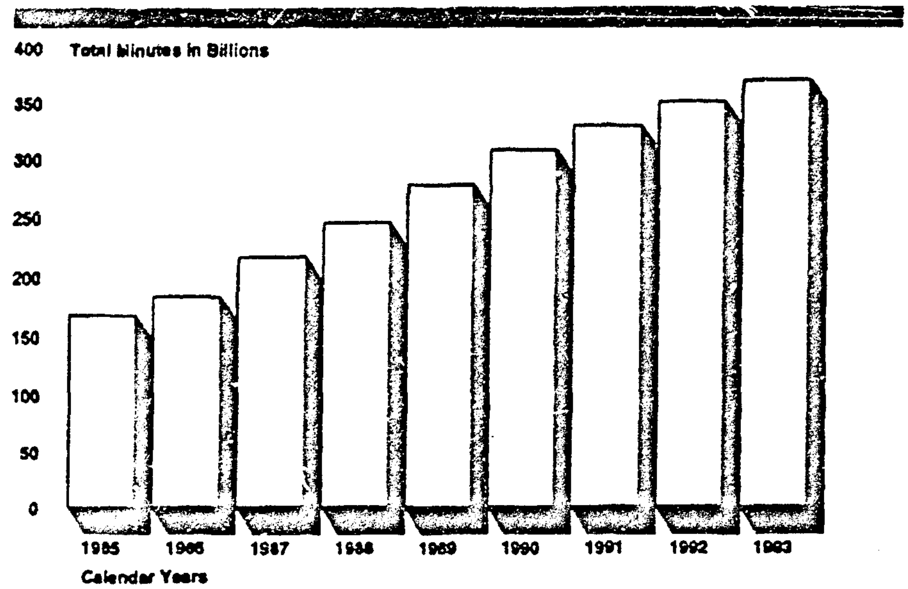
Figure 2.2: Price of a 5-Minute Mid-Day Call From Washington, D.C., to San Francisco, California, 1984-93



Note: Rates are for calls using AT&T and are based on published tariffs, not including discounts.

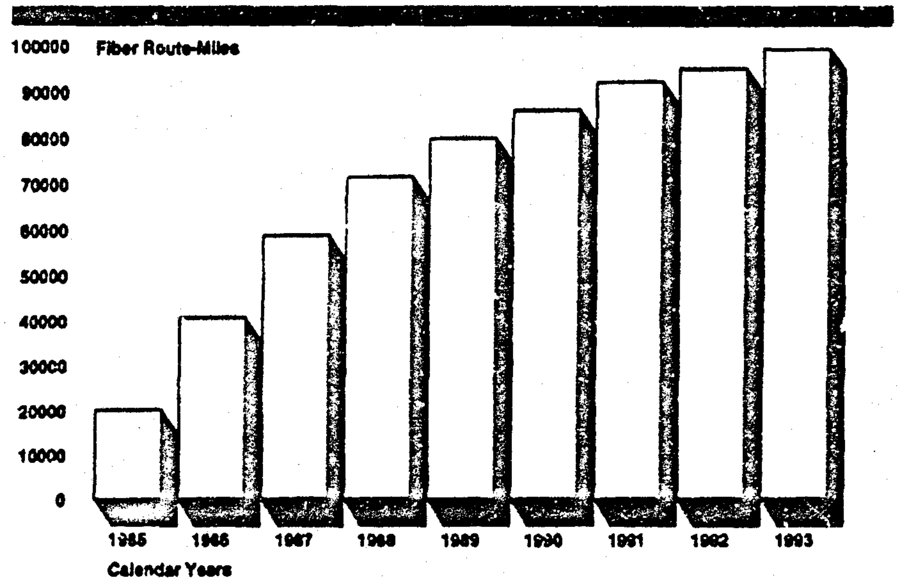
[6] A representative of a long-distance carriers' association noted that tariffed rates do not represent what consumers actually pay because the tariffed rates do not reflect the variety of discount plans offered by the industry. The representative said rates actually paid by consumers are lower than tariffed rates.

Figure 2.3: Total Long-Distance Usage, 1985-93



Technological advances and increased competition spurred AT&T, Sprint, and MCI to install all-digital and/or fiber-optic networks. In 1987, AT&T estimated that it would finish installing an all-digital network by 2010. However, after investing $6 billion since 1984, AT&T had completed its installation by 1991. Between 1986 and 1993, the total miles of fiber-optic cable installed by all long-distance companies increased nearly fivefold, from about 20,000 to nearly 100,000, as shown in figure 2.4.

Figure 2.4: Miles of Fiber-Optic Cable in the Long-Distance Infrastructure, 1985-93



Note: According to FCC, route miles in the long-distance infrastructure are essentially equal to sheath-miles.

These improvements in the long-distance infrastructure have provided the large capacity that the Information Superhighway could conceivably require. However, local infrastructure will also need to have greater capacity if the Information Superhighway is to reach homes, schools, and businesses. Because the local infrastructure contains many times the route-miles of the long-distance infrastructure, these capacity improvements will be more costly. The administration, the Congress, and the telecommunications industry agree in principle that competition in the local telecommunications markets would help increase consumer choices, lower prices, and stimulate the required investment, just as it has in the long-distance market.

New Competitors in Local Telephone Service Are Stimulating Infrastructure Improvements

Some competition has emerged at the local level. Companies called competitive access providers (CAP) have begun providing businesses with alternatives to the local telephone companies in some markets. These companies use their own local infrastructure and switches to route calls directly to and from the long-distance network, thus bypassing the local telephone companies' access charges. While competition from CAPs is expected to grow, telephone service provided by cable television companies and wireless communications providers—cellular, satellite, and PCS—could also increase competition in the local telephone service market.[7] Finally, some utility companies are installing fiber-optic cable to assist in demand management.[8] These companies are considering providing some telecommunications services over this infrastructure.

Existing and anticipated competition, as well as relaxed pricing regulations, has stimulated cost reductions and upgrades in local networks. Between 1988 and 1992, the BOCs reduced their operating expenses, excluding depreciation, by 27 percent and cut the number of employees per 10,000 access lines by nearly 7 percent. A recent industry analysis forecasts that similar reductions could occur over the next 5 years. According to the President and Chief Executive Officer of one CAP, local telephone companies reduced their rates for large business customers by up to 30 percent in several markets within 2 years after companies such as his began offering competitive alternatives. This official also cited improvements in customer service, such as reductions in installation and repair times.

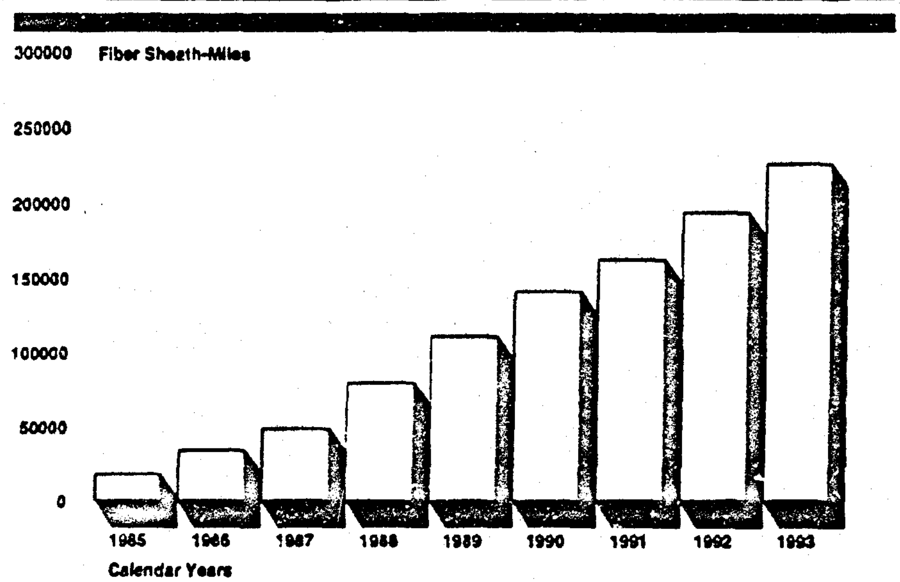
Local telephone companies have begun installing fiber-optic cable, as figure 2.5 shows. While the total number of fiber sheath-miles in the local telephone infrastructure may appear high compared with the total number of route-miles in the long-distance infrastructure, the local infrastructure is many times larger and more distributed. Consequently, it is more costly to upgrade. As figure 2.6 shows, only 6 percent of the local infrastructure contained fiber-optic cable at the end of 1993. Most of these exist primarily in the central arteries of the local infrastructure and do not extend to residences. To carry the Information Superhighway through a wired

[7] Currently, carriers attempting to compete with local telephone companies, or those providing adjunct (e.g., cellular) services, must pay local telephone companies for interconnection when completing calls in the local network. However, local telephone companies do not pay similar access fees when delivering a call to other carriers, such as cellular service providers. This lack of reciprocal pricing could be an obstacle for competitors.

[8] Through demand management, utilities encourage consumers to use major appliances during off-peak hours, thereby reducing peak-capacity requirements and deferring the need to build additional power plants.

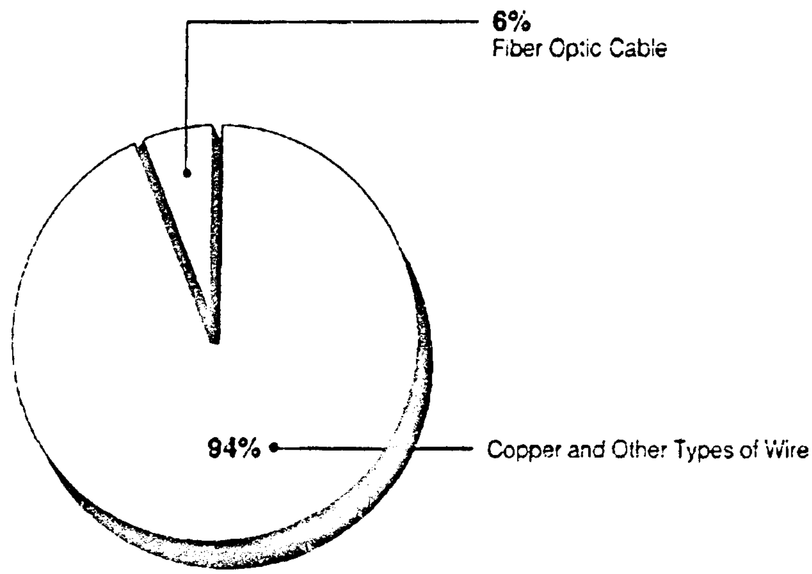
network to homes, schools, and businesses, high-capacity wires, such as fiber-optic or coaxial cables, will be needed throughout the local infrastructure.[9]

Figure 2.5: Miles of Fiber-Optic Cable Installed by Local Telephone Companies, 1985-93



[9]Wireless networks, such as PCS, will also have a role in the development of the Information Superhighway.

Figure 2.6: Fiber-Optic Cable as a Percentage of All Wire in the Local Infrastructure as of December 31, 1993



Note: According to FCC, most wire other than fiber-optic cable is copper.

Source: Preliminary Statistics of Communications Common Carriers, FCC, July 5, 1994, Washington, D.C.

Additionally, the BOCs and GTE have installed Integrated Services Digital Network (ISDN) technology—which allows the simultaneous transmission of voice and data—in about 25 percent of their local networks, and they have introduced advanced network control functions that permit a multitude of advanced applications in over 63 percent of their networks. These percentages are expected to increase to 45 percent and 90 percent, respectively, by 1996, according to a recent industry analysis. These upgrades will enable these companies to provide advanced services such as caller identification, return call, repeat call, and ultimately, video entertainment.

Cost estimates to fully deploy fiber-optics in the local infrastructure vary widely. Some are as high as $500 billion to upgrade the existing local infrastructure to provide the full range of multimedia services, such as video-on-demand, high-speed data transmission, home shopping, and

interactive games. However, others claim that telephone companies would, on their own accord, spend a large percentage of that sum in the course of replacing copper wire with fiber-optic cable in the coming decades, and the incremental cost of accelerating fiber deployment would be only about 5 percent higher than the total that the telephone companies would have otherwise spent.

Current Restrictions Limit Growth of Competition

Existing restrictions and the 1982 AT&T consent decree limit the extent to which competition between telephone and cable television services can grow at the local level. A number of states have laws that restrict or prohibit competition in the provision of local telephone service. In addition, the Cable Communications Policy Act of 1984 prohibits local telephone companies from providing video services within their local service area. Finally, the 1982 consent decree prohibits the BOCs from entering a number of lines of business.

Many States Prohibit Local Telephone Service Competition

A number of states have laws that prohibit or restrict competition in the provision of local telephone service. According to the National Association of Regulatory Utility Commissioners, 24 states prohibit and another 16 partially restrict local competition. If these restrictions were eliminated, increased local competition could come from a number of sources. The cable television infrastructure could be used to carry telephone service, since it can be upgraded to provide such service and is readily accessible to about 95 percent of U.S. homes. This would allow cable television companies to offer local telephone service in competition with local telephone companies. Additionally, by purchasing cable television companies outside their geographic regions, local telephone companies could begin competing with one another by providing local telephone service through their cable subsidiaries. Similarly, long-distance companies could provide local telephone service through joint ventures with cable companies. Outside the cable infrastructure, CAPs could begin operating in states where local competition had heretofore been prohibited, or companies could build their own local infrastructure, as MCI plans to do.

In general, state laws prohibiting local competition allow regulators to maintain a pricing structure for local telephone service that furthers the goal of universal service—the availability of affordably priced rudimentary

telephone service to all Americans.[10] As discussed in chapter 3, many observers believe that states have pursued this goal by requiring the local telephone companies to allocate their costs in such a way that the local telephone company can provide residential and rural telephone service at rates that are below fully distributed costs, while charging rates above fully distributed costs for long-distance access to the local infrastructure and for intrastate long-distance calls. Because greater competition generally leads to prices that are more in accordance with cost considerations, allowing competitors to enter the local telephone market may make the current cost allocation system unworkable. Chapter 3 discusses this issue in more detail.

Cable Regulations Limit Local Telephone Companies' Competitive Options

Some telephone companies want to provide video programming services in competition with local cable companies within their local service area, but existing restrictions generally prevent local telephone companies from doing so. Section 613(b) of the Communications Act of 1934, as amended, generally prohibits local telephone companies from providing video programming over their own systems, either directly or through an affiliate, to subscribers in their telephone service area.[11] This provision is commonly referred to as the "telco/cable cross-ownership restriction."

The telco/cable cross-ownership restriction had its genesis in a similar restriction imposed by FCC in 1970. At that time, FCC found that local telephone companies had the potential to discriminate against independent cable television providers in favor of their own affiliates in granting access to poles for attaching cable television lines. While the issue of pole access was addressed in major part by the Pole Attachment Act of 1978, FCC noted concern that local telephone companies could hide the costs of providing cable television in their telephone rate structures, a practice called cross-subsidizing. This practice would result in higher telephone rates and increased cash flow from the telephone companies' monopoly telephone service customers, which local telephone companies

[10] Also, in many states, public utility commissions believe that the local telephone service market is a natural monopoly.

[11] The provision of video services by a BOC within its service area would also conflict with the AT&T consent decree, since operation of a cable system may involve crossing of its local access and transport area boundaries—the geographic limits of the telephone company's service area. The AT&T consent decree prohibits BOCs from providing services that extend beyond these boundaries. While some BOCs have plans to provide video services outside their service areas, these require that the court grant a waiver from the consent decree's provision.

could then use to underprice cable television competitors, force them out of business, and thus extend their monopolies to cable television.[12]

The 1982 Consent Decree Imposed Line-Of-Business Restrictions on the BOCs

The 1982 AT&T consent decree, approved by the U.S. district court, initially prohibited the BOCs from (1) providing long-distance services, (2) manufacturing or providing telecommunication equipment, (3) manufacturing customer premises equipment, (4) providing information services, and (5) providing nontelecommunications products or services, such as operating a cafeteria on company premises.[13] These restrictions are referred to as line-of-business restrictions.

The court recognized that after divestiture, the BOCs would possess a monopoly over local telephone service in their geographic areas but concluded that this condition alone would not require the BOCs to be barred from all competitive markets. Rather, the court concluded that a line-of-business restriction on the BOCs would be permissible only if there was a substantial possibility that the BOCs would use their monopoly power to impede competition in a particular market. Two relevant factors were considered: (1) whether the BOCs would actually have the incentive and opportunity to act anticompetitively and (2) whether the participation of the BOCs would contribute to the creation of a competitive market. In addition, the court also considered important public policies, such as the effects of the restrictions on the rates for local telephone services. Applying this analysis, the court found the five previously noted restrictions to be warranted.

The court recognized, however, that over time it was probable that the BOCs would lose the ability to leverage their monopoly power in competitive markets. Accordingly, the court required that the decree explicitly provide a mechanism for removing line-of-business restrictions. The competitive entry test imposed by the modified consent decree provides for the removal of a line-of-business restriction upon a showing "that there is no substantial possibility that [a BOC] could use its monopoly power to impede competition in the market it seeks to enter."

[12]Federal and state rate regulations attempt to ensure that costs associated with any nonregulated services (such as information services) are not allocated to regulated local telephone service. However, as the regulatory process is complex and confronts many uncertainties, not all inappropriate cost shifting can be uncovered by regulators.

[13]The restriction on nontelecommunication products or services was lifted in 1987, and the prohibition on providing information services was lifted in 1991.

Some Competitive Barriers Have Been Eliminated, While Others Have Been Questioned

States, FCC, and the courts have taken a number of actions that have affected telecommunications.

- Some states have changed their laws to allow more local telephone competition in recent years, and others are considering such changes.
- FCC reevaluated its cable cross-ownership policy, noting that the cable television industry has achieved substantial growth and that the potential benefits of increased competition outweighed the risk of anticompetitive behavior. In 1992, FCC recommended that the Congress remove the statutory provision against local telephone companies providing video services, subject to appropriate safeguards.
- Two district courts have ruled that the cable cross-ownership restriction is an unconstitutional burden on the telephone companies' right to free speech under the First Amendment.[14]
- The U.S. district court removed the BOCs' restriction on providing nontelecommunications products and services in 1987 and information services in 1991.[15]

House and Senate Have Proposed Legislation

Recognizing that technological advances have eroded and will continue to erode the distinctions between the competitive and noncompetitive segments of the telecommunications industry, the Congress is considering legislation aimed at encouraging competition while protecting consumers from monopolistic pricing practices as the transition to competition occurs. The House passed H.R. 3626—The Antitrust and Communications Reform Act of 1994 and H.R. 3636, the National Communications Competition and Information Infrastructure Act of 1994—on June 28, 1994, and combined these into one bill, numbered and titled as the former. Senate bill S. 1822—The Communications Act of 1994—has been reported out of the Committee on Commerce, Science, and Transportation but as of September 23, 1994, had not reached the Senate floor for consideration.

The bills, among other things, provide the conditions that must be met before a BOC can provide long-distance services; allow telephone companies to offer video programming services in their market areas

[14]See, U.S. West Inc. v. United States, No. C93-1523R (W.D. Wash. June 15, 1994); Chesapeake & Potomac Tel. Co. v. United States, 830 F. Supp. 909 (E.D. Va. 1993).

[15]In U.S. v. Western Elec. Co., 900 F.2d 283, 305 (D.C. Cir. 1990), the court of appeals concluded that the consent decree's test for removing line-of-business restrictions applied only to contested modifications. For uncontested modifications—when all the parties to an agreement agree to the lifting of a restriction—the court found that a public interest test is appropriate. Because the removal of the information services restriction was uncontested, the court specified that the public interest standard be applied to remove this restriction.

under specific conditions and safeguards; provide requirements for the FCC to establish procedures to ensure preservation of the principle of universal service; preempt state and local laws that prohibit telecommunications competition; and provide requirements for interconnection and nondiscriminatory access to telecommunications facilities and equipment. Appendix III provides highlights of selected provisions of these bills.

Market Power of Local Telephone Companies Presents Challenges in Fostering Competition

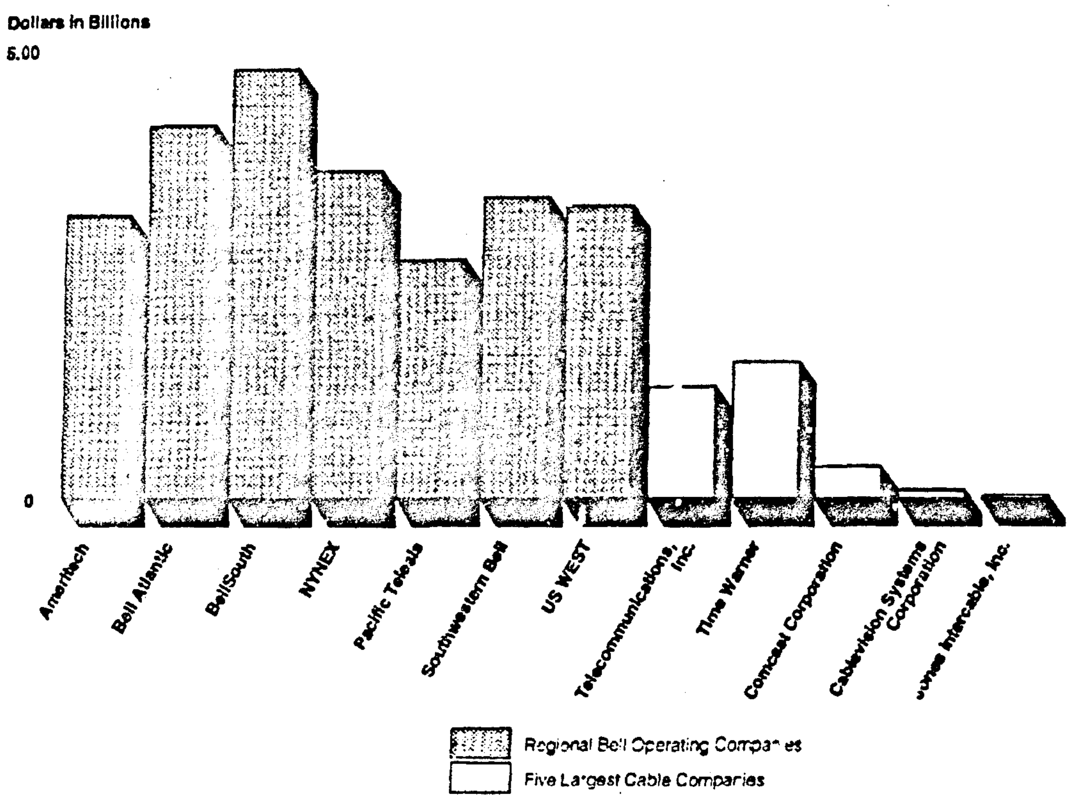
The proposed telecommunications legislation has generated intense debate over whether and to what extent consumers will need protection from the local telephone companies' potentially anticompetitive use of market power. A central issue in the debate is whether the recent emergence of CAPS provides sufficient competition to safely remove the existing controls on the BOCS and if not, what conditions would indicate that sufficient competition exists and what safeguards would be needed to protect consumers from the BOCS' market power. The BOCS raised the issue of regulatory parity, claiming that if state regulations are modified to allow long-distance, cable television, or other businesses to provide local telephone service, the BOCS should be allowed similar flexibility. The BOCS claim that the local telephone market is already competitive, citing the increasing presence of CAPS and potential competition from cable television companies and long-distance companies offering local telephone service.

On the other hand, a recent industry analysis reported that CAPS—the major current source of local competition—have attracted only about $250 million out of $27 billion in long-distance access business. Consequently, long-distance companies argue that the BOCS dominate the local market nearly as much as they did in 1984 when the consent decree was implemented, and therefore more competition at the local level is needed before the BOCS can be allowed to provide long-distance services.

In addition, other groups, including the cable television industry, have cited the strong financial position of the seven regional Bell operating companies. The regional companies' ready access to cash, relative to that of cable companies, could provide them with a competitive advantage in making the required investment to provide diversified services. As figure 2.7 shows, the regional companies' 1993 cash flow, defined as the cash received from customers minus the cash paid for operating expenses, ranged from $2.7 billion to $4.8 billion. Most of this cash flow was invested in capital. In contrast, the financial position of the five largest cable companies—likely future competitors of the BOCS—was not nearly as

strong. While Telecommunications, Inc., and Time Warner had 1993 cash flows of $1.25 billion and $1.53 billion,[16] respectively, the combined cash flow of the remaining three cable companies totaled only $470 million.[17]

Figure 2.7: 1993 Cash Flow of Regional Bell Operating Companies and the Five Largest Cable Companies



Conclusions

The outcome of the debate over when and how to remove restrictions on competition will affect the development of the Information Superhighway. On the one hand, removing state regulations that bar local competition and allowing local telephone companies to provide video services in competition with the local cable television companies could benefit

[16]About 85 percent of Time Warner's $1.53 billion operating revenues are from noncable sources.

[17]Telecommunication: Financial Information on 16 Telephone and Cable Companies (GAO/RCED/AIMD-94-221FS, July 8, 1994).

consumers and accelerate the local infrastructure upgrades needed to bring the Information Superhighway to homes, businesses, and schools. On the other hand, removing regulations either too soon or without implementing adequate safeguards to prevent monopolistic pricing practices could drive out rather than encourage competition.

Competition and Technology Affect Universal Service

The prospect of competition in the local telephone service market, as well as advances in telecommunications technology, require that several decisions be made about universal service—the long-standing public policy goal that affordable rudimentary telephone service be accessible to all individuals. These decisions involve (1) procedural issues concerning how to fund universal service in a more competitive environment and (2) value judgments on whether and how the package of services included under the universal service and universal access umbrella should be broadened.

Funding Mechanism for Universal Service Will Need Revision in a Competitive Environment

Currently, universal service is provided through a complex system of implicit and explicit subsidies provided through the federal and state regulatory process and through federally managed programs. However, because the majority of universal service funding comes from services that, through the state regulatory process, are priced above fully distributed costs, the funding process could break down as competitors price these services lower than the incumbent telephone company.

Various Policies and Programs Help Fund Universal Service

Federal and state regulators have developed a system of cost allocation and recovery that keeps residential and rural rates at affordable levels in order to meet the objective of universal service—providing everyone with access to affordable rudimentary telephone service. Since the rate-making process has traditionally been based on the cost of providing services, many observers believe that rates for local residential and rural service would be higher than existing levels if based on fully distributed costs. Federal and state regulators have maintained low rates for these services through a system that allocates some local telephone infrastructure costs to other services.

Historically, FCC and state regulators worked with AT&T and other local telephone companies to establish affordable local residential rates by allocating some of the cost of the local infrastructure to inter- and intrastate long-distance service. Because fewer costs were allocated to local telephone service, rates were held at lower levels than would have otherwise been the case. After divestiture, the pricing mechanism used to fund low local residential and rural rates became more complex as regulators were now dealing with many more companies providing service in numerous market segments of the telephone industry. However, the key elements of providing affordable local residential and rural telephone service continued to invoive cost allocation and recovery as in the pre-divestiture era.

Today, as before the divestiture, regulators require the local telephone companies to allocate some of the costs of the local telephone infrastructure to other services. The following summarizes two major ways that cost allocation occurs.

- FCC's policies require long-distance companies to pay to the local telephone companies a per-minute Carrier Common Line Charge (access fee). These revenues are used to recover part of the costs of the local telephone infrastructure that are assigned to interstate long-distance service. Because many local infrastructure costs do not vary with actual usage, charging per-minute fees amounts to pricing access above fully distributed cost. A 1994 industry analysis estimated that long-distance access charges were between 35 percent and 60 percent above cost-based pricing levels, while residential and rural local-service rates were 35 percent to 40 percent below what they would be under cost-based prices.[18]
- Regulators in many states allocate a significant portion of the cost of the local telephone infrastructure to intrastate long-distance services. This practice results in above-cost rates for access fees and per-minute usage on these types of calls, thereby helping to provide affordable rural and residential telephone service.

While the above noted programs provide a large share of the cost of providing affordable residential and rural telephone service, several other federal and state policies and programs help to promote universal service. A brief description of some of these programs follows.

- The Universal Service Fund assists "high-cost" local telephone companies, which the FCC defines as those that have an average cost per access line exceeding 115 percent of the national average. The fund helps these high-cost companies (that tend to be located in rural areas) to provide local telephone service at rates that are similar to national averages. The Universal Service Fund is supported by fees levied on long-distance carriers according to the number of customers choosing their company for long-distance service.
- FCC administers two programs aimed at providing direct subsidies to low-income individuals. The Link-up Program helps offset low-income subscribers' initial installation costs and encourages telephone companies to offer installment payments. The Lifeline Program helps defray the cost of monthly service for low-income residents by waiving up to $3.50 of the

[18] *A result of charging prices that are higher than fully distributed cost is that consumers will choose to use less of the service than is economically efficient.*

federal monthly subscriber line charge. Eligibility criteria for these programs vary from state to state.

- The Rural Electrification Administration, Department of Agriculture, provides low-cost loans and loan guarantees to rural telephone companies and cooperatives.

Revised Funding Mechanism Is Needed

If competition in the local telephone service market is allowed, new procedures will be required to ensure the continuation of universal service. While inter- and intrastate long-distance access charges and intrastate long-distance rates have traditionally provided the major source of funds used to keep residential and rural rates low, competitors are likely to compete primarily for heavy users of inter- and intrastate long-distance services in states where regulations permit local competition. Currently, these competitors have no obligation to provide or contribute toward the provision of local residential and rural telephone service. Local telephone companies believe that losing this source of funds to provide universal service could place a financial strain on high-cost companies and on some subscribers. Hence, as competition becomes more widespread, a revised funding mechanism for universal service is required.

Current System of Allocating Universal Service Subsidies Questioned

An additional issue that policy makers will need to consider is how to distribute subsidies. Currently, cost allocation mechanisms and other programs designed to further universal service are based primarily on the pricing of different types of services and on the cost structure of providers (i.e., residential service and high-cost telephone companies), rather than on an individual subscriber's ability to pay. Consequently, subsidies may not go where they are most needed.

While over 94 percent of U.S. residences had telephone service in 1993, the distribution varies according to household income. For example, while more than 99 percent of households with incomes over $40,000 had telephone service, less than 90 percent with incomes under $10,000 had service, and only 73 percent of households with incomes below $5,000 had service. Some industry observers have pointed out that a means test should be used as the principal criterion to allocate universal service subsidies.

Questions Exist About Whether and Which Additional Services Should Be Provided or Universally Accessible

The Information Superhighway could make available a host of advanced services to businesses, schools, medical centers, and the population at large. Redefining universal service in this new environment raises questions on two levels. First, what advanced services should be provided to everyone? Second, what, if any, additional services should be accessible to everyone as options?

Decisions Are Required on What Services Should Be Universally Provided

Currently, universal service consists of rudimentary telephone service, the definition of which has evolved over time. Initially, rudimentary service was considered a multiparty line. Gradually, the number of parties decreased until today, single-party lines are standard. In some locations, touch-tone service has been included in rudimentary telephone service.

As the Information Superhighway develops, a vastly expanded array of telecommunications services could become available. For example, consumers may have on-line access to health care information, allowing them to become more actively involved in their own health care, thereby reducing unnecessary visits to the doctor. Consumers could also have better access to government information and services. While these services could benefit society, building the infrastructure to provide these expanded services to every home in America will be costly—up to $500 billion by some estimates—and some question exists as to which services the average citizen needs or wants. Although a recent survey indicated significant consumer demand for interactive services, the survey also showed that over 40 percent of the respondents in the households surveyed were either undecided or unwilling to pay for additional services.

In addition to facing infrastructure costs, consumers may need new appliances to access Information Superhighway services. For access to rudimentary telephone service, only a telephone was required. Those accessing the Information Superhighway's services may need a personal computer, interactive television, or other wired or wireless devices, in addition to a conventional telephone. These appliances are not commonly found in homes of the economically disadvantaged. Providing the required appliances to those who cannot otherwise afford them will increase the cost of providing universal service.

Decisions Needed on Whether Services Should Be Universally Available as Options

An additional issue is determining which Information Superhighway services should be universally accessible as options, beyond those services made available to everyone under universal service. To make these services available, infrastructure improvements may be required beyond those required to provide universal service. However, these costs could be mitigated, depending on how decision makers define "availability." Additional services could be deemed available if consumers can obtain them at central locations, such as at a public library, which would be less costly than making them available to every home. Whatever the results of these decisions, consumers would ultimately pay the cost of providing the required infrastructure. However, the installation and appliance costs, if needed to receive optional services, would probably not be subsidized.

Conclusions

The prospect of greater competition in the local telephone services market raises the question of how to maintain the pricing structures that help to promote universal service. Some form of funding for universal service, supported by providers of telecommunications services, is probably appropriate. A more difficult issue, however, is determining which telecommunications services should be provided as part of the universal service package, which should be available as options, and how to pay for them. Providing Information Superhighway services to all schools, hospitals, and libraries would provide social benefits that could justify some of the cost. However, building the infrastructure needed to make every Information Superhighway service available to every home and business would be costly, and not everyone may need or desire every service.

Information Superhighway Poses Technical Challenges

The success of the Information Superhighway will also depend on how well industry and government address several technical challenges. An effective Information Superhighway requires technology that can ensure (1) security, privacy, and reliability and (2) the smooth flow of information and provide number portability—the freedom to change carriers without changing telephone numbers.[19] A systems perspective is needed to ensure that these challenges are addressed in a coordinated fashion.

Technological Advances Pose Challenges to Security, Privacy, and Reliability

Concentrated data bases, widely distributed networks, and the increasing sophistication of criminals pose threats to computer security and information privacy. Advances in communications and data encryption technologies hamper federal law enforcement efforts, while federal efforts to address this issue have caused controversy. Concentrated data bases also heighten the need for ensuring reliability, since the failure of a single component of a system can render millions of records inaccessible.

Security Threat Has Increased

While information security has long been an important issue, a number of factors increase the risks in today's electronic age. First, electronic recordkeeping concentrates large volumes of data in a single location, thereby rendering the consequences of unauthorized access more severe. Second, networked computers widely disperse electronic traffic, increasing the potential for unauthorized intercept. Third, criminals are gaining technical skills that enable them to foil sophisticated security systems.

Attacks against the Internet illustrate potential vulnerabilities. In 1988, a worm—a malignant computer program that reproduces itself automatically—invaded the Internet and denied service to thousands of people working at the nation's major research centers. Again, in 1994, intruders managed to obtain the names and passwords of 100,000 people who use the Internet at certain locations and to conceal the theft.

The Department of Defense's Advanced Research Projects Agency has established a Computer Emergency Response Team to help the Internet community respond to attacks. This and other incident response teams now serve as focal points for identifying security vulnerabilities. While response teams can identify problems and recommend corrective action, the manufacturers and network users themselves are responsible for

[19] While we recognize that intellectual property rights also pose significant issues for telecommunications decision makers, we did does not address this area. The Information Infrastructure Task Force, chaired by the Secretary of Commerce, is preparing a report focusing on copyright law and its application and effectiveness in the context of the Information Superhighway.

taking action. To ensure security on the Information Superhighway, additional procedures will be required to accurately identify the users, verify their authority to access information, and prevent malicious interference with software programs or modification of data files.

Privacy Needs to Be Ensured

Systems for protecting privacy should enable individuals to determine when, how, and to what extent personal information is collected and used. However, if not properly implemented and managed, the technologies that provide the means to manage massive volumes of personal information also increase the risk that this information may be abused. This risk is heightened by

- the widespread use of common identifiers, such as Social Security numbers, to select, track, and link electronic records;
- the dramatic increase in the number of widely interconnected systems, which increases opportunities for unauthorized access;
- the growth of large data bases and the increasing sophistication of applications that allow the rapid matching of millions of records and the development of detailed computer profiles on individuals; and
- the increasing sophistication of computer criminals and their growing ability to secretly penetrate computer systems and retrieve massive amounts of confidential information.

Today's patchwork of information privacy laws, practices, and technical safeguards may fall short of ensuring the privacy of personal information maintained in thousands of widely interconnected government and private computer systems. In 1990, we reported that in over 900 of the largest federal computer systems containing privacy data, 11 percent did not require user authentication, 40 percent had no intrusion detection controls, and 6 percent had no access controls.[20] A lack of such controls can lead to egregious abuses. For example, in 1993 we reported that scores of Internal Revenue Service employees had accessed the agency's data bases to issue fraudulent refunds or had browsed the taxpayer accounts of friends, relatives, neighbors, and celebrities.[21]

Recognizing that personal data need better protection, the administration's Information Infrastructure Task Force is studying the issue. A working

[20] Computers and Privacy: How the Government Obtains, Verifies, Uses, and Protects Personal Data (GAO/IMTEC-90-70BR, Aug. 3, 1990).

[21] IRS Information Systems: Weaknesses Increase Risk of Fraud and Impair Reliability of Management Information (GAO/AIMD-93-34, Sept. 22, 1993).

group has identified a number of tasks, including (1) scoping the nature of the privacy problem; (2) developing a statement of fair information practices and determining the responsible organizations and individuals; and (3) identifying gaps in existing laws, recommending changes, and drafting legislation, if necessary.

Technology Could Impair Law Enforcement and Intelligence Capabilities

Sophisticated encryption prevents third parties, including law enforcement and intelligence agencies, from monitoring encrypted messages, while digital communication makes wiretapping increasingly difficult. The federal government is attempting to address these issues, but its efforts to date have generated considerable controversy. The government's strategy includes (1) a major new federal encryption initiative known as the "Clipper Chip," recently renamed the "Key Encryption Standard," to facilitate court-ordered wiretapping and (2) proposed legislation that would ensure that telecommunication equipment and services can meet law enforcement's wiretapping requirements.

Efforts to Decipher Encrypted Messages Are Controversial

To enable federal authorities to decrypt intercepted messages, the federal government is seeking the computer hardware industry's voluntary cooperation to install the Clipper Chip in all its telephone communications hardware. The chip contains a unique key that is used to encrypt and decrypt messages. This unique key is then split into two components and delivered to government agencies, acting as escrow agents, for safekeeping. To decipher information encoded using the Clipper Chip in the course of court-authorized wiretapping, federal authorities can obtain the unique key from the escrow agents.

The Clipper Chip initiative has generated considerable controversy within the information industry. According to the Computer System Security and Privacy Advisory Board, created by the Congress in 1987 to advise the Secretary of Commerce and the Director of the National Institute of Standards and Technology on security and privacy issues, the federal government has not (1) clearly articulated the problem that the Clipper Chip attempts to resolve, (2) considered other potential alternatives, or (3) fully examined the chip's legal and economic implications.

In response to the controversy, the administration is reviewing its policy on the Clipper Chip. The administration stated that the Clipper Chip would not be used for computer or video networks and expressed a willingness

to work with computer industry representatives and privacy advocates to design a system more acceptable to all.

New Legislation Would Require Wiretap Capability in Telecommunications Devices

Recognizing that new telecommunications devices can be developed that are invulnerable to court-ordered wiretaps, a bill has been introduced that would, among other things, generally require communications carriers to deploy equipment and services that can accommodate law enforcement needs. The bill would require that a communications carrier's equipment and services allow law enforcement personnel to intercept a subscriber's communications and obtain reasonably available call-identifying information about the origin and destination of communications. Because subjects of wiretaps on mobile communications devices may cross carrier boundaries, the bill would require that a carrier inform government personnel of the identity of the carrier to whom the signal was transferred. The bill would authorize $500 million over 4 years for the Department of Justice to reimburse telecommunications carriers for expenses that they incur in complying with these requirements.

Assurance of Reliability Is Needed

As more and more telecommunications traffic is concentrated in fewer, high-capacity channels, a failure by any one element of the Information Superhighway could become increasingly damaging. For example, in June 1991 two separate telephone outages at opposite ends of the country eliminated local telephone service to 8 million people and affected emergency services. A few months later, AT&T suffered a massive outage in New York City that cut most long-distance telephone communications to and from the city as well as air traffic to the area's major airports. FCC noted that this outage resulted in significant loss of the Federal Aviation Administration's radar sites, radio channels, and computer links. This resulted in 1,174 canceled or delayed flights and about 85,000 inconvenienced passengers. More than 7 hours passed before full service was restored.[22]

The federal government and industry have undertaken a variety of efforts to improve the reliability of telecommunications systems. For example, FCC formed the Network Reliability Council following serious network outages in 1991. Additionally, the administration's Information Infrastructure Task Force has formed a network reliability working group, and industry has developed a number of mutual aid and restoration agreements to permit the temporary sharing of resources and rerouting of information traffic and services through other systems.

[22] Telecommunications: Interruptions of Telephone Service (GAO/RCED-93-79FS, Mar. 5, 1993).

Added attention to system reliability will be required, however, as the Information Superhighway grows to its full potential. Although mutual aid agreements exist, the current approach relies primarily on individual carriers to manage their own networks. As the telecommunications industry grows more competitive, these arrangements may prove inadequate. Additionally, the diversity of products and operators on the Information Superhighway may increase the difficulty of diagnosing and correcting problems.

Interoperability Is Required

Interoperability—defined as the ability of two systems to transfer information easily—will be critical to establishing the "seamless web" of networks and equipment envisioned for the Information Superhighway. Number portability, which would allow consumers to switch telecommunications carriers without changing their telephone numbers, is a second aspect of interoperability that will be important to the success of the superhighway.

Equipment and Systems Interoperability Is Required

A seamless web of equipment and networks would allow equipment and systems, manufactured by different companies and using different technologies, to transfer information without delay. Complete interoperability would, for example, allow a social worker in Appalachia to prepare a message on a lap-top computer and transmit it via wireless technology to a receiver. From there, the message might be carried over wires to a satellite earth station, beamed up to a satellite, and beamed back to earth in San Francisco. The message might then be sent over wires to a broadcast television station and then, ultimately, to the addressee's interactive television. The addressee might respond to the message via the reverse route.

Each component of the Information Superhighway—the lap-top computers, wire infrastructures and switches, satellites, television stations, and interactive televisions—will likely be built by a variety of private concerns. The success of the Information Superhighway will hinge on the ability of these technologies to transfer information easily and accurately, allowing voice, video, and data to flow unimpeded throughout the network.

Some Information Superhighway Facilities Lack Interoperability

Interoperability problems have surfaced in today's information technology. For example, as the BOCs implemented their Integrated Services Digital Networks (ISDN), interoperability problems developed

because each BOC had purchased equipment built to differing standards from different suppliers.[23] Videoconferencing also faces interoperability problems because over a dozen incompatible videoconferencing systems are currently on the market. While these systems can interoperate to a degree, certain incompatibilities degrade the picture's quality and preclude the use of advanced features. In the future, interoperability problems are likely to continue, since many of the emerging, sophisticated technologies that are expected to play a role in the Information Superhighway, such as asynchronous transfer mode (ATM),[24] have not realized an acceptable level of interoperability.

Some Efforts Are Under Way to Promote Interoperability

The private sector and the National Institute of Standards and Technology are addressing ISDN interoperability problems. Additionally, a consortium of government agencies, industry, and academia has formed the National Information Infrastructure Test Bed to develop standards and test applications in a wide variety of fields, including health care, mineral and gas exploration, education, and entertainment. Finally, the Alliance for Telecommunications Industry Solutions (formerly called the Exchange Carriers' Standards Association) has formed an ad hoc committee to develop product interoperability tests. The test methodology is available to the industry for use whenever new hardware or software emerges on the market.

Interoperability of Developing Technology Is Not Yet Assured

If data, voice, and video are to move unimpeded over the Information Superhighway, further work will be required to ensure interoperability. For example, the Alliance's ad hoc committee addressed only one facet of the Information Superhighway. The committee considered intra-network, product-to-product, and stand-alone equipment modeling and testing to be outside its charter. Other aspects of existing networks, such as interoperability testing requirements for newer technologies, were also not addressed. The Information Superhighway will likely consist of many systems and subsystems, developed by a variety of private sector entities, each with its own—often proprietary—set of standards.

Superhighway Presents Telephone Numbering Challenges

Development of a telephone numbering system that is interchangeable among telecommunications carriers will be important to the development of the Information Superhighway. Consumers' ability to change carriers without changing telephone numbers will play a critical role in developing

[23]ISDN allows the simultaneous use of telephone lines for transmitting data and voice. (See app. I for a detailed explanation of ISDN.)

[24]See appendix I for a detailed description of ATM and other advanced telecommunications technologies.

competition, which, as discussed in chapter 2, will be a key element in spurring development of the Information Superhighway. Number portability, as the concept is called, requires that subscribers, rather than physical locations, be assigned a permanent personal telephone number that would not change if the subscriber changed carriers. While such a system was developed for commercial "800" numbers, no such numbering system has yet been devised for individuals.

Bellcore[25] plans to implement an expanded numbering system in 1995 that would vastly increase the quantity of available telephone numbers. The additional numbers would facilitate the assignment of numbers to individuals and could allow them to switch carriers without changing numbers. However, no entity is currently developing the data base architecture required to implement the system. Bellcore, the entity that has administered the telephone numbering system, plans to relinquish its voluntary performance of this task as soon as FCC finds a replacement.

Conclusions

If the Information Superhighway is to be successful, privacy, security, reliability, interoperability, and numbering systems must be addressed from a systems perspective. Individuals, governments, and businesses will not use the superhighway without assurances of security, privacy, and a reasonable expectation of reliability. The superhighway cannot function as a seamless web without interoperability. To permit individuals to switch carriers without changing telephone numbers, data bases are required that have yet to be developed. The Information Superhighway will be developed by a number of diverse entities, none of which are likely to be in a position to address these challenges from a systems standpoint. Some mechanism will be needed to ensure that all the challenges are met to allow the Information Superhighway to function as planned. We will examine these and other issues in greater detail in a forthcoming report.

[25] Bell Communications Research, also known as Bellcore, is a research organization funded by the BOCs.

Telecommunications

Advances in telecommunications technology are driving many of the changes occurring in the telecommunications industry today. Because many readers may not be familiar with this technology, this appendix provides a general overview of the technological developments in the field. In addition, this report contains a glossary of telecommunications terms.

Telecommunications is the electronic transmission of information of any type, such as data, television pictures, sound, and facsimile. Telecommunications frequently involves the use of a network, which is a group of interconnected communications facilities and devices used to transmit information. Examples of telecommunications networks include the telephone networks, the television broadcast networks, the Internet "network of networks," and private corporate computer networks.

Network Capacity

Current telecommunications networks are designed to transmit one or more of three types of information—audio, video, and/or other types of digital information, such as text—each of which places different demands on the underlying network. These demands differ in terms of the "space" required on a network and how the space is used. The space requirement is called the bandwidth and the ability of a network to accommodate bandwidth is called its transmission capacity. Conversational telephone audio traffic requires a transmission capacity of about 64,000 digital bits per second (referred to as 64 kilobits per second). Additionally, telephone audio traffic requires uninterrupted interactive processing, meaning that the signals must travel quickly between the sender and receiver without unacceptable delays.

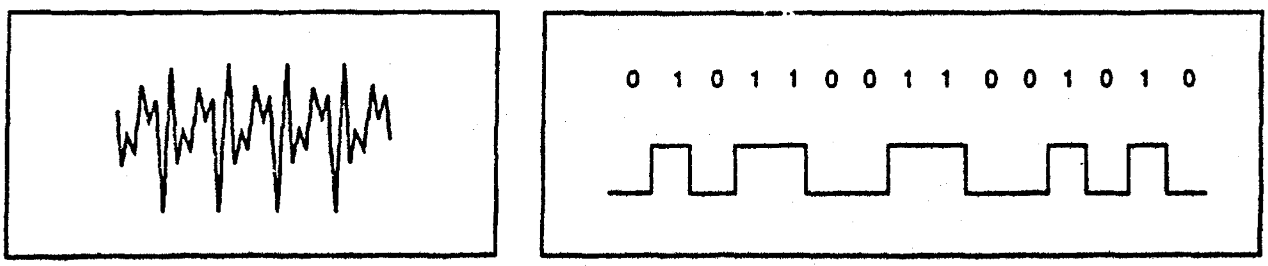
In contrast, video transmission requires significantly more capacity than does audio or data transmission. For example, digital television needs a transmission channel with an uncompressed capacity[26] of at least 30 million bits per second (referred to as 30 megabits per second), which is over 450 times the capacity required for telephone conversation. However, video transmissions are generally not interactive and also require uninterrupted operation. Text traffic, such as electronic mail, generally does not require real-time processing and can therefore run at a variety of speeds, depending on the capacity of the network.

[26]Compression allows the transmission of data using less capacity.

Analog Versus Digital Signal Format

Electronically transmitted information is sent in either a digital or an analog format. As figure I.1 shows, electronic analog signals are continuous electromagnetic waves, while digital signals are usually represented by ones and zeroes.

Figure I.1: Analog and Digital Signals



Analog signal

Digital signal

Historically, most signals have been sent in an analog format. However, the digital format is gaining favor because it offers cost, transmission, and quality control advantages. For example, traditional television broadcasts have been transmitted in an analog format, but the emerging direct broadcast satellite telecasts will be sent to the home in a digital format.[27]

Telecommunications Protocols

All electronic signals—digital or analog—must be transmitted in an organized manner to ensure that the communications devices in a network send and receive the signals accurately and efficiently. Therefore, transmission devices employ "communication protocols" that establish rules for organizing the transmitted signals. Different protocols have emerged as standards for each particular type of network. These standards can emerge by virtue of their widespread acceptance or they may be developed by an influential group and then adopted by the industry for its products. For example, the Transmission Control Protocol/Internet Protocol has become the Internet standard through its widespread acceptance, while the National Television System Committee developed the U.S. television standard, which FCC and the industry adopted. These differing communications standards can create interoperability problems

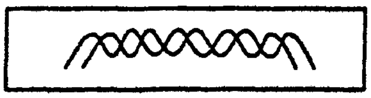
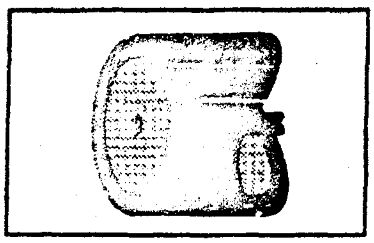
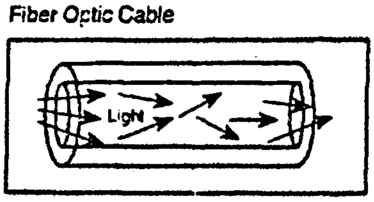
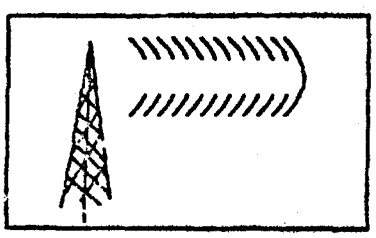
[27]Direct-broadcast satellite transmissions will be sent to residences as digital signals and then changed into analog signals for viewing on standard televisions.

when attempting to connect different types of networks. For example, although television sets and computer screens both provide video displays, these displays are not interoperable because televisions use an analog display standard, while most computers use a digital display standard.

Telecommunications Transmission Media

All signals, whether digital or analog, travel via some type of medium to reach their destinations. The predominant electronic transmission media are copper "twisted pair" wire, coaxial wire, fiber-optic cable, and over-the-air signals. Figure I.2 shows the advantages and disadvantages of each type of medium.

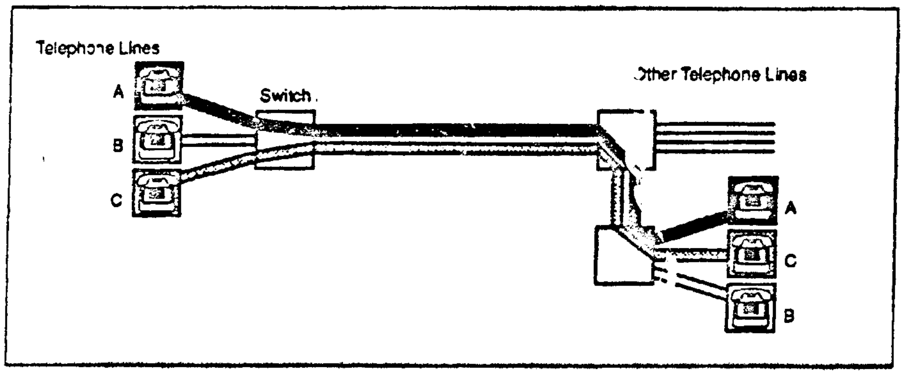
Figure I.2: Transmission Media and Their Advantages and Disadvantages

Medium	Advantages	Disadvantages
Copper Twisted Pair Wire 	• Is used extensively in residential telephone systems • Is inexpensive • Is widespread	• Has low information capacity • Is susceptible to electronic interference
Coaxial Cable 	• Is used extensively for cable TV • Accessible to 95 percent of U.S. households • Has sufficient capacity to handle most advanced telecommunications applications likely to be used in residences	• Is used primarily in one-way TV networks • Will require additional switching equipment in most cable TV networks to permit two-way communication
Fiber Optic Cable 	• Has very high information capacity • Is relatively secure • Is not susceptible to electronic interference	• Is expensive to install supporting equipment • Not installed in most residential areas
Over-the-Air 	• Enhances mobility • Does not require wire conduits	• Is relatively unsecure • Requires allocation of the frequency spectrum, a finite resource • Is susceptible to electronic interference

Network Switching

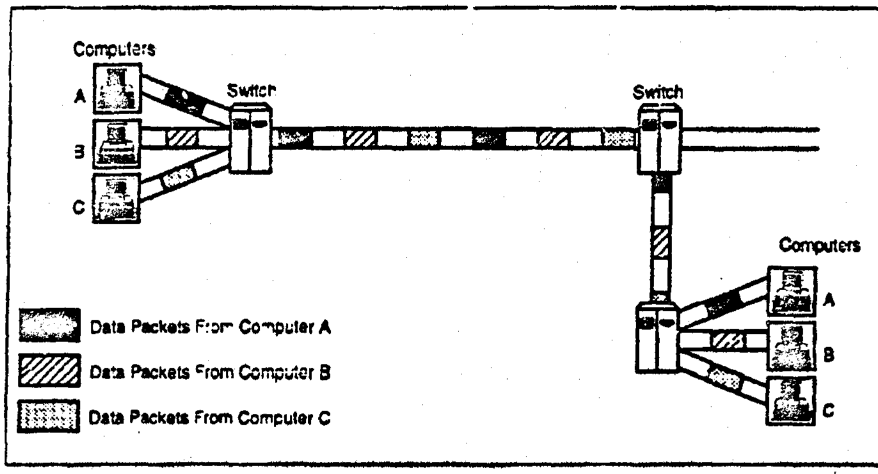
The four previously mentioned media are components of networks. Many networks also use switching and routing devices to send signals to their intended destinations. Circuit switching and packet switching are common switching designs. In a circuit-switching network (see fig. I.3), as in a traditional telephone network, a connection is made at a switching center that physically connects the calling and receiving parties and maintains this connection for as long as needed. No other audio, text, or video information can be sent over this circuit as long as the connection remains intact.

Figure I.3: Representation of a Circuit-Switching Network



In a packet-switching network, such as the Internet, digital data are organized into "packets" and sent through a computer network along the best route available between the source and the destination. A transmitted file, for example, may be broken up into many packets, and these packets may take different paths across the network and then be reassembled at their destination. For most applications, a packet-switching network is more efficient than a circuit-switching network because many data packet sources may use the same communications line simultaneously (see fig. I.4). However, a circuit-switching network tends to have more consistent performance than a packet-switching network because there is no competition from other communications devices using the line.

Figure I.4: Representation of a Packet-Switching Network



Interactive Networks

Interactive networks allow two-way communication. Providing an interactive service requires that signals travel rapidly to and from the source and the destination of the activity. The telephone network is an example of an interactive network designed to carry voice traffic.

Currently, most residential access to interactive services is through telephone lines, which are generally copper twisted-pair wires that lack the ability to carry interactive video traffic. Consequently, interactive services at the residential level are generally limited to audio and text applications. In contrast, cable television networks carry video traffic into residences using coaxial cable, which has a higher capacity than copper twisted-pair wire. However, the cable networks currently do not have the switching infrastructure needed to provide interactive services to the home.

Fiber-optic cable has higher capacity than either copper twisted-pair or coaxial cable. Although the cost of using fiber-optic cable is decreasing, its cost has historically limited its use to high-traffic trunk routes. More recently, as costs decrease, some telecommunications providers are extending fiber-optic cable from the trunk routes to locations closer to residences. However, extending fiber-optic cable all the way from the trunk routes to individual residences remains costly. Thus, a hybrid coaxial-fiber system will most likely be used to provide residential access to interactive services.

Emerging Technologies

Several types of telecommunications technologies are emerging that could overcome current technical obstacles or provide new or advanced services. Among these technologies are data compression, techniques for sending audio traffic over a data network, and network enhancements that provide improved or interactive services.

Data compression refers to techniques for compacting digital signals for more efficient transmission or storage. Compressed data can be sent faster, more cheaply, and over lower-capacity networks than can uncompressed data. Data compression is particularly useful for digital video transmission because (1) video normally requires a relatively high network capacity and (2) some data can be lost during compression without significantly affecting the picture's quality. Compression allows, for example, an increase in the number of available residential cable TV channels from 125 to over 500.

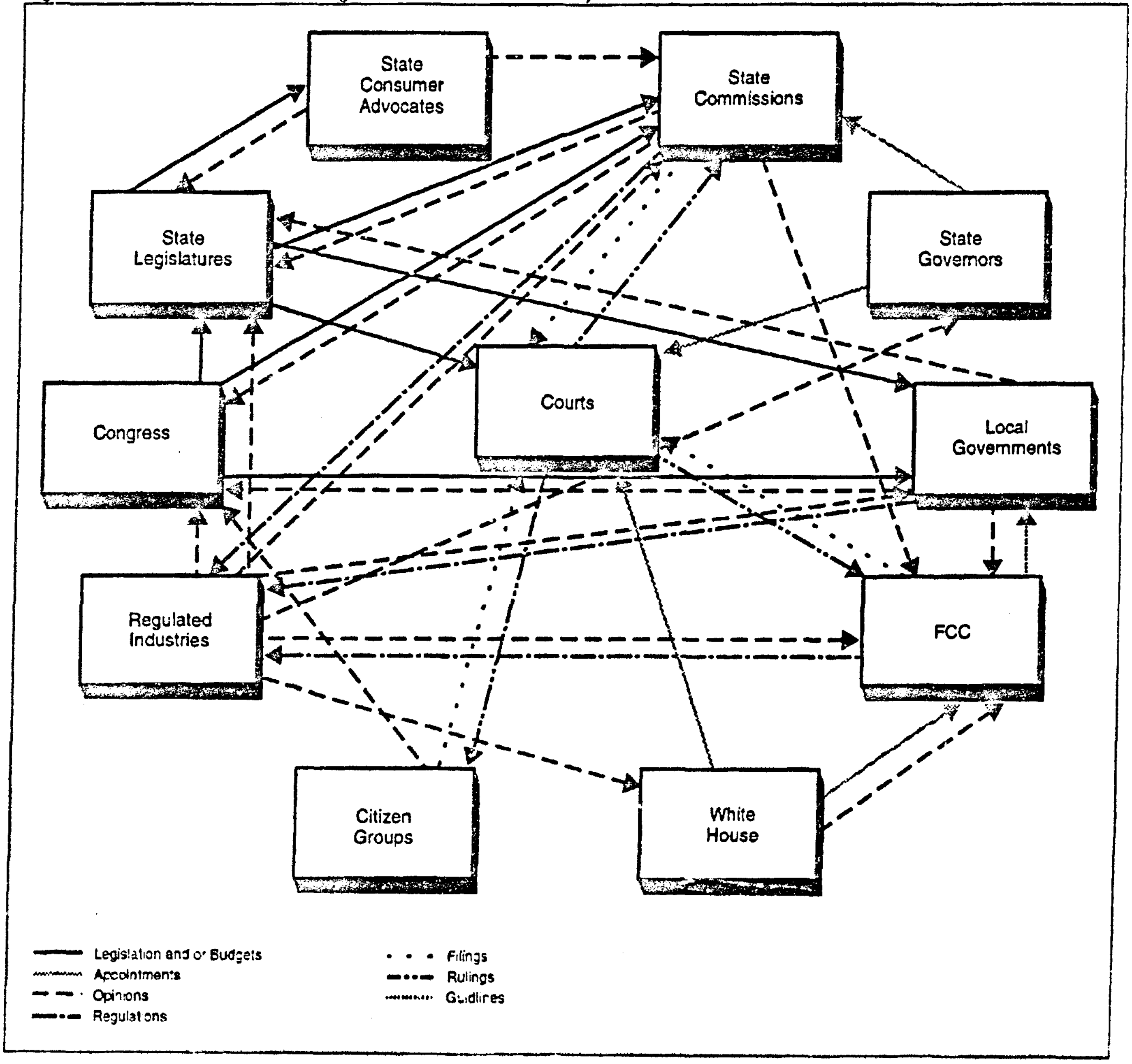
Because packet-switched networks are more efficient than circuit-switched networks, some organizations are developing techniques for sending audio traffic over a packet-switched network. One technique, referred to as asynchronous transfer mode (ATM), places digitized audio signals into packets and sends them over a high-speed packet-switched network. The federal government has developed ATM test beds as part of its National Research and Education Network initiative, and several telecommunications firms are now offering commercial ATM technologies. Government researchers are investigating very-high-speed networks that challenge the limits of the technology.

Some emerging technologies may provide improved or interactive services over the current telecommunications infrastructure. One such technology, called the asymmetrical digital subscriber line, is being tested by the Bell Atlantic telephone company. This technology, if proven successful, will allow video programming to travel over copper twisted-pair telephone lines while allowing concurrent telephone service. Bell Atlantic is testing this technology in northern Virginia. Another example is the implementation of ISDN technology. ISDN is designed to provide interactive telephone and data services simultaneously over a standard copper telephone line. Combined with video compression techniques, ISDN can provide interactive video service over a standard telephone line.

Regulators and Businesses in the Telecommunications Industry

Regulators have had substantial impact on the telecommunications industry. Regulators seek to promote universal service, ensure markets' stability, protect property rights, promote multiple information sources, and protect consumers from unfair pricing practices. The regulatory structure is administered and influenced through a complex web of state and local governments, FCC, the Congress, the courts, and special interest groups, as figure II.1 indicates. In addition, the telecommunications industry consists of many businesses, each of which is affected in different ways by telecommunications policy.

Figure II.1: The Arena for Formulating Telecommunications Policy



A Number of Bodies Formulate and Influence Telecommunications Policy

The following briefly discusses the functions of the entities primarily responsible for formulating telecommunications policy and regulations.

Federal Communications Commission

FCC was established by the 1934 Communications Act as an independent regulatory body responsible for regulating interstate and foreign communication by radio and wire. According to the 1934 act, FCC's telecommunications policy goal is to make available, as far as possible, to all the people of the United States a rapid, efficient, nationwide, and worldwide wire and radio communication service with adequate facilities at reasonable charges. To achieve this goal, FCC believes it must promote efficiency, universal service, reasonable charges, and innovative services.

The Department of Justice

The Department enforces antitrust laws. In 1974, the Department filed suit against AT&T, alleging a number of anticompetitive abuses under the Sherman Antitrust Act. The suit culminated in a consent decree that separated AT&T's long-distance and local telephone service industries. The Department, together with the U.S. district courts, administers the provisions of the consent decree.

The Courts

The federal courts interpret telecommunications legislation and review FCC's actions. The U.S. district court has administered the provisions of the AT&T consent decree, including whether and when the BOCs can begin providing long-distance service, manufacture telecommunications equipment, and provide information services. Pending legislation would shift some of these responsibilities to FCC and the Justice Department.

State and Local Governments

State and local governments generally regulate intrastate telephone services. Among other things, they (1) establish regulatory policies, (2) control the entry of other telephone service providers, and (3) regulate rates.

In addition, a number of organizations exist to assist in formulating public policy and addressing technical issues associated with the Information Superhighway. Examples follow.

Department of Commerce's National Telecommunications and Information Administration

This agency serves as the President's expert adviser on telecommunications matters, including economic and technological advancement and industry regulation. The agency manages the federal government's use of portions of the radio frequency spectrum, coordinates federal telecommunications assistance to state and local governments, and studies and evaluates telecommunications research and development and the impact of the convergence of computer and communications technology.

Interagency Information Infrastructure Task Force

This task force works with the Congress and the private sector to propose the policies and initiatives needed to accelerate the deployment of the Information Superhighway. The task force is chaired by the Secretary of Commerce and includes representatives of the key federal agencies involved in telecommunications and information policy.

Advisory Council on the National Information Infrastructure

The Advisory Council provides advice from the private sector to the Interagency Infrastructure Task Force on (1) the appropriate roles of the private and public sectors in national infrastructure development; (2) the administration's vision for the evolution of the infrastructure; (3) privacy, security, and copyright issues; (4) national strategies for maximizing the interconnection and interoperability of communications networks; and (5) universal access policies. The council is composed of members from industry, labor, academia, public interest groups, and state and local governments.

Telecommunications Industry Consists of Many Players

In addition to local and long-distance telephone companies, the telecommunications industry includes a variety of other businesses. Competitive access providers (CAP) compete with local telephone companies for certain types of business in specific locations, while other players include cable, satellite, and broadcast television; cellular and satellite telephone; on-line information services (e.g., Compuserve and Prodigy); and a host of hardware and software manufacturers. Advances in technology have shaped the way these companies have developed and competed. Some companies are in their formative stages, such as direct-broadcast satellite television and satellite telephone services. Others, such as cellular telephone and on-line information services, while established only within the past decade, have achieved substantial growth and now play significant roles in the industry.

Competitive Access Providers

CAPS provide competitive local telephone service alternatives by linking customers to long-distance networks and to other local customers. CAPS currently focus primarily on large-volume customers in major business districts. Many have installed their own fiber-optic infrastructure which facilitates high-capacity services such as videoconferencing. Estimates on the number of CAPS range between 30 and 45. CAPS' customers believe they receive high-quality services, quick response times, and economical prices. However, many states prohibit competition with the local telephone company, and in others, CAPS face franchise fees and other restrictions that do not apply to the local telephone company.

Cable Television Companies

Cable television companies provide a wide variety of programming that is sent to residences mainly over coaxial cable rather than over the air, as in broadcast television. Cable companies retransmit local television broadcast signals and may also offer programs available via satellite transmission, such as C-Span and Cable News Network.

Regulation of the cable television industry has historically involved a mixture of policies, regulations, rules, and procedures administered by federal, state, and local entities. The 1984 Cable Communications Policy Act deregulated the industry. However, in response to continually increasing cable rates, the Congress enacted the Cable Television Consumer Protection and Competition Act of 1992 (commonly known as the 1992 Cable Act), which requires cable rate regulation in areas where effective competition does not exist. FCC estimated that rate reregulation would affect up to three-quarters of the cable systems and cable subscribers across the country.

Personal Communications Services and Cellular Telecommunication Companies

Cellular telephone companies offer mobility for customers when providing local service, some long-distance service, and some data services. The cellular industry generally consists of two providers per geographic region and is generally unregulated. Personal Communications Services—a lightweight, more portable, and versatile cousin of cellular telephones that is just now emerging—is expected to provide additional data as well as video services. Although FCC allocates spectrum for these industries, they are not generally subject to comprehensive federal and state regulation.

Satellite-Based Services

Satellite television and satellite telephone services can reach rural areas not served by wires. The size and cost of satellite television antennas has

been a drawback of this technology. However, two direct-broadcast satellite companies, which will deliver programming to customers using 18-inch dish antennas, are planning to initiate operations in the near future. The companies plan to offer the antennas for about $700 initially but anticipate lower prices as the number of subscriptions increases. In addition, several companies are developing satellite-based telephone systems. The size and cost of this equipment and the expected rates for using the systems present challenges.

Broadcast Companies

Broadcast companies, which provide consumers with the only free radio and television services, are subject to FCC spectrum allocation and content guidelines. Broadcasters believe they are potential participants in the Information Superhighway, since they reach nearly 100 percent of all homes and will soon be able to broadcast data to pagers and fax machines. In addition, broadcasters would like to offer enhanced advertising services. For example, if a viewer desired additional information about an advertised product, the viewer could interactively obtain information on the product's availability or price or perhaps on the location of the nearest dealer.

Digital television is expected to represent the next generation in television technology. Because information in digital format can be compressed into less space than information in analog format, more frequency spectrum is expected to become available when digital television arrives. Broadcasters hope to deliver advanced services over this new-found capacity.

The 1934 Communications Act and certain provisions of the 1984 and 1992 cable acts govern television and radio broadcasters. The 1984 Cable Communications Policy Act prohibits certain types of television-cable cross-ownership. FCC's licenses limit broadcasters' use of allocated spectrum to providing free over-the-air broadcast signals. These rules are intended to ensure multiple ownership and a diverse array of mass media providers. However, broadcasters perceive their regulatory structure as a barrier to operating in other lines of businesses.

Electric Utility Companies

Electric utilities plan to use the Information Superhighway's technology, and some are considering providing expanded services. Some utilities have been installing fiber-optic cable in their internal communications networks to monitor customers' energy consumption and read meters for billing purposes. These utilities hope to assist customers in managing their

demand by suggesting the use of major appliances during off-peak hours. Reduced peak energy demand could postpone the need for utilities to build new power plants. However, because these services use only a portion of the fiber-optic cable's capacity, some utility companies are considering leasing the excess capacity to other communications service providers or possibly providing local telephone service.

Electric utilities are regulated at the state level for intrastate generation, distribution, transmission, and sales by public utility commissions or equivalent agencies and at the federal level for interstate transmissions and wholesale sales by the Federal Energy Regulatory Commission. Existing regulations prevent some of these companies from engaging in non-utility lines of business.

Highlights of Selected Provisions of House and Senate Telecommunications Bills

House—H.R. 3626	Senate—S. 1822
Long distance	
Interstate A BOC would have to get approval from both the U.S. Attorney General and the FCC in order to provide interstate long-distance service. The U.S. Attorney General must find no "substantial possibility" that the BOC or its affiliates could use monopoly power to impede competition in the market it seeks to enter in order to approve a BOC request for long-distance market entry. FCC must find that approval is "consistent with the public interest, convenience, and necessity". Intrastate BOCs may provide intrastate long-distance services without obtaining U.S. Attorney General or FCC approval if the state involved has approved or authorized such services. States must consider the potential effects of approval on competition and the public interest. Within 90 days of receiving notice of state approval, the U.S. Attorney General can pursue civil action to prevent the service.	The Senate bill requires the same U.S. Attorney General and FCC approvals but extends them to both interstate and intrastate long-distance service, and only through a separate subsidiary. For FCC approval of in-region long-distance service originating in any area where the BOC is the dominant provider of local telephone service, the FCC must find that there are no barriers to market entry, such as state laws or other regulations, and that the BOC is meeting its telecommunications obligations such as interconnection and nondiscriminatory access. Also, the FCC cannot approve an application before it has issued regulations implementing universal service requirements, or until 21 months have passed since enactment of the bill, whichever is earlier.

House—H.R. 3626	Senate—S. 1822
Video programming	
Common carriers, such as local telephone companies, may offer video programming directly to their subscribers through an affiliate. Any common carrier providing these services must make its television channel capacity available to any video service provider, consistent with FCC regulations, which the Commission must prescribe within 1 year. FCC must also prescribe regulations prohibiting telephone companies and cable operators from cross-subsidizing. That is, telephone companies could not include in telephone rates, any funds to help pay for video programming. Likewise, cable operators could not help pay for telephone operations with cable revenues.	Local telephone companies may offer video programming to their subscribers through a subsidiary, or make their television channel capacity available to other video providers, but only if preconditions similar to those required for in-region long-distance service have been met. The Senate bill would allow FCC to exempt local telephone companies and cable companies from the subsidiary requirement if it determines that a subsidiary is no longer necessary for the protection of consumers, competition, or the public interest. The Senate bill also prohibits cross-subsidization. Cable companies are permitted to offer telephone services in their franchise areas, but only through a subsidiary.

House—H.R. 3626	Senate—S. 1822
Universal service	
FCC must, within 30 days of enactment, convene a joint federal-state board to recommend how to preserve universal service and what services should be universal. The board may recommend to FCC changes to the definition of "from time to time."	The Senate bill contains universal service provisions that are similar to those in the House bill. The FCC would have to convene the joint board within 1 month of enactment and at least once every 6 years.
One of the guiding principles to be followed by the joint board is the pursuit of reasonably comparable services, including advanced telecommunications, at "just and reasonable rates" for rural and urban areas.	The Senate bill requires that the FCC establish a Universal Service Fund within 18 months. An independent administrator would control and manage the fund. FCC and the states would determine distribution of the funds.[a]
	The Senate bill provides a guiding principle for the joint board that is similar to that in the House bill on pursuit of comparable services at reasonable rates for rural and urban areas.

[a]As this report went to printing, the Senate Committee on Commerce, Science, and Transportation was drafting a floor amendment that would revise the provision requiring FCC to establish a Universal Service Fund.

House—H.R. 3626	Senate—S.1822
Federal preemption of state and local laws	
After 1 year of enactment, no state or local government may prohibit any person or any carrier providing interstate or intrastate telecommunications or information services from entering the market. They also may not prohibit any person or any carrier providing such services from exercising interconnection or access rights.	The Senate bill bars state or local laws and regulations that prohibit the ability of any entity to provide any interstate or intrastate telecommunications service. Additionally, a state may not impose requirements on a carrier for intrastate services that are inconsistent with those imposed by FCC for interstate services.

House—H.R. 3626	Senate—S.1822
Equal access	
Common carriers that furnish communications services must provide interconnection with other providers' facilities and equipment, in accordance with any applicable FCC regulations. Upon reasonable request by other telecommunications carriers, local telephone companies must provide equal access to and interconnection with their facilities in a manner that achieves full interoperability. Whenever technically feasible and economically reasonable, local telephone companies must offer unbundled features, functions, and capabilities. Within 30 days of enactment, the FCC must convene a Federal-State Joint Board to make recommendations to the FCC; and within 1 year of enactment the FCC must issue regulations that implement the equal access and interconnection requirements. Rural telephone companies are exempt from these requirements unless the FCC determines that compliance is economically workable, competitively fair, technologically feasible, or in the public interest. FCC may modify the requirements for local telephone companies that have fewer than 500,000 access lines installed nationwide.	Common carriers are similarly required to provide equal access and interconnection on an unbundled basis where technically and economically feasible, and without any unreasonable conditions or restrictions on the resale or sharing of those services or functions. FCC shall modify the requirements for rural telephone companies at a company's request or on FCC's own initiative. With carrier justification, FCC may waive or modify the requirements for a telecommunications carrier if the carrier has fewer than 2 percent of the nation's subscriber lines installed.

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Glossary

Except where noted, we based the definitions in this glossary on those contained in Computer Dictionary: The Comprehensive Standard for Business, School, Library, and Home, Microsoft Press, 1991, Washington, D.C.

Analog

A term applied to any device, usually electronic, that represents values by a continuously variable physical property, such as voltage in an electronic circuit. An analog device can represent an infinite number of values within the range the device can handle. In contrast, digital representation maps values onto discrete numbers, limiting the possible range of values to the resolution of the digital device.

Architecture

A general term referring to the structure of all or part of a computer system. The term also covers the design of system software, such as the operating system, as well as refers to the combination of hardware and basic software that links the machines on a computer network. Computer architecture refers to an entire structure and to the details needed to make it functional. Thus, computer architecture covers computer systems, chips, circuits, and system programs but typically does not cover applications, which are required to perform a task but not to make the system run.

Asynchronous Operation

Generally, an operation that proceeds independently of any timing mechanism, such as a clock. In communications, for example, two modems communicating asynchronously rely upon each one sending the other start and stop signals in order to pace the exchange of information.

Bandwidth

In communications, the difference between the highest and lowest frequencies in a given range. For example, a telephone accommodates a bandwidth of 3000 hertz (Hz), the difference between the lowest (300 Hz) and highest (3300 Hz) frequencies it can carry. In computer networks, greater bandwidth indicates faster data-transfer capabilities.

Bit

Short for "binary digit"; either 1 or 0 in the binary number system. In processing and storage, a bit is the smallest unit of information handled by a computer and is represented physically by an element such as a single pulse sent through a circuit or a small spot on a magnetic disk capable of storing either a 1 or a 0. Considered singly, bits convey little information a

human would consider meaningful. In groups of eight, however, bits become the familiar bytes used to represent all types of information, including the letters of the alphabet and the digits.

Broadband Network

A type of local area network on which transmissions travel as radio-frequency signals over separate inbound and outbound channels. Stations on a broadband network are connected by coaxial or fiber-optic cable. The cable itself can be made to carry data, voice, and video simultaneously over multiple transmission channels. This complex transmission is accomplished by the technique called frequency-division multiplexing, in which individual channels are separated by frequency and buffered from one another by guard bands of frequencies that are not used for transmission. A broadband network is capable of high-speed operation (20 megabits or more), but it is more expensive than a baseband network and can be difficult to install. Such a network is based on the same technology that is used by cable television. Broadband transmission is sometimes called wideband transmission.

Circuit Switching

A method of opening communications lines, as through the telephone system, creating a physical link between the initiating and receiving parties. In circuit switching, the connection is made at a switching center, which physically connects the two parties and maintains an open line between them for as long as needed. Circuit switching is typically used in modem communications on the dial-up telephone network, and it is also used on a smaller scale in privately maintained communications networks.

Coaxial Cable

Often referred to as coax or coax cable. A cable that consists of two conductors, a center wire inside a cylindrical shield that is grounded. The shield is typically made of braided wire and is insulated from the center wire. The shield minimizes electrical and radio-frequency interference; signals in a coaxial cable do not affect nearby components, and potential interference from these components does not affect the signal carried on the cable.

Communications Protocol

A set of rules or standards designed to enable computers to connect with one another and to exchange information with as little error as possible. The word "protocol" is used, sometimes confusingly, in reference to a multitude of standards affecting different aspects of communication. Some

standards affect hardware connections, while other standards govern data transmission. Still other protocols govern file transfer, and others define the methods by which messages are passed around the stations on a local area network. Taken as a whole, these various and sometimes conflicting protocols represent attempts to facilitate communication among computers of different makes and models.

Computer Network	A group of computers and associated devices that are connected by communications facilities. A network can involve permanent connections, such as cables, or temporary connections made through telephone or other communications links. A network can be as small as a local area network consisting of a few computers, printers, and other devices, or it can consist of many small and large computers distributed over a vast geographic area. Small or large, a computer network exists to provide computer users with the means of communicating and transferring information electronically. Some types of communication are simple user-to-user messages; others, of the type known as distributed processes, can involve several computers and the sharing of workloads or cooperative efforts in performing a task.
Data	Plural of the Latin datum, meaning an item of information. The term is frequently used for the singular as well as the plural form of the noun.
Data Compression	A term applied to various means of compacting information for more efficient transmission or storage, used in such areas as data communication, data base management systems, facsimile transmission, and CD-ROM publishing. One common compression technique, called key-word encode, replaces each frequently occurring word—such as the or here—with a 2-byte token, thus saving one or more bytes of storage for every instance of that word in a text file.
Digital	Related to digits or the way they are represented. In computing, digital is virtually synonymous with binary because the computers familiar to most people process information coded as combinations of binary digits, or bits—zeros and ones. One bit can represent at most two values—0 or 1. Two bits can represent up to 4 different values—00, 01, 11, and 10. Eight bits can represent 256 values—00000000, 00000001, 00000011, and so on.

Direct Broadcast Satellite	Employs a satellite to beam TV programming and information directly to homes. The first direct broadcast satellite was launched in December 1993 to relay signals from a ground station to 18-inch satellite dishes located at residences. Direct broadcast signals are sent in a digital format so as to increase signal capacity and improve reception quality.
Electronic Mail	Messages transmitted over a communications network. Electronic mail, or e-mail, is a computer-to-computer (or terminal-to-terminal) version of interoffice mail or the postal service. Used on both local area networks and larger communications networks, electronic mail enables users to send and receive messages and in some instances graphics or voice messages, either to individual recipients or in broadcast form to larger groups. Delivered messages are stored in electronic mailboxes assigned to users on the network and can be viewed, saved, or deleted by the recipient. Depending on the capabilities of the electronic mail program, users can also forward mail, include "carbon" copies, request return receipts, attach files, and edit messages with a text editor. With systems on which the mail program can remain active in the background while the user works on other tasks, recipients can also be informed when new mail arrives and can choose to view the message immediately or save it for later viewing.
Encryption[28]	The transformation of data into a form readable only by using the appropriate key, held only by authorized parties. The key rearranges the data into its original form by reversing the encryption.
Fiber-Optics	A method of transmitting light beams along optical fibers. A light beam, such as that produced in a laser, can be modulated to carry information. A single fiber-optic channel can carry significantly more information than most other means of information transmission. Optical fibers are thin strands of glass or other transparent material.
Gateway	A device used to connect dissimilar networks—networks using different communications protocols—so that information can be passed from one to the other. Unlike a bridge, which transfers information between similar networks, a gateway both transfers information and converts it to a form

[28]This definition is based on information in Protecting Privacy in Computerized Medical Information, U.S. Office of Technology Assessment, Sept. 1993, U.S. Government Printing Office, Washington, D.C.

compatible with the protocols used by the second network for transport and delivery.

Gigabyte

The precise meaning often varies with the context; strictly, a gigabyte is 1 billion bytes. In reference to computers, however, bytes are often expressed in multiples of powers of two. Therefore, a gigabyte can also be either 1,000 megabytes or 1,024 megabytes, where a megabyte is considered to be 1,048,576 bytes.

HDTV

Acronym for high-definition television, a method of transmitting and receiving television signals that produces a picture with much greater resolution and clarity than standard television technology. With suitable standards, the quality of a high-definition television picture can approach that of a movie screen. The standards for high-definition television are not yet established, and competing technologies are under development in Europe, Japan, and the United States.

Interactive

Operating in a back-and-forth, often conversational manner, as when a user enters a question or command and the system immediately responds. Microcomputers are interactive machines; this interactivity is one of the features that make them approachable and easy to use.

Interface

The point at which a connection is made between two elements so that they can work with one another. In computing, different types of interfacing occur on different levels, ranging from highly visible user interfaces that enable people to communicate with programs to often invisible, yet necessary, hardware interfaces that connect devices and components inside the computer.

User interfaces consist of the graphical design, commands, prompts, and other devices that enable a user to interact with a program. Microcomputers have three basic types of user interfaces (which are not necessarily mutually exclusive):

- The command-line interface responds to commands typed by the user.
- The menu-based interface (also called the menu-driven interface), used by many application programs, offers the user a choice of command words

that can be activated by typing a letter, pressing a direction key, or pointing with a mouse.

- The graphical interface, characteristic of windowing programs, presents the user with a visual representation of some metaphor, such as a desk-top, and allows the user to control not only menu choices but also the size, layout, and contents of one or more on-screen "windows" or working areas.

At less-visible software levels within the computer are other types of interfaces, such as those that enable an application to work with the operating system and those that enable an operating system to work with the computer's hardware. In hardware, interfaces are cards, plugs, and other devices that connect pieces of hardware with the computer so that information can be moved from place to place. Standardized data-transfer interfaces enable connections between computers and printers, hard disks, and other devices.

Internet

Abbreviation for "internetwork." In communications, a set of computer networks—possibly dissimilar—joined together by means of gateways that handle data transfer and the conversion of messages from the sending network to the protocols used by the receiving network (with packets if necessary). When capitalized, the term "Internet" refers to the collection of networks and gateways that use the Transmission Control Protocol/Internet Protocol suite of protocols.

ISDN

Abbreviation for "Integrated Services Digital Network"—a worldwide digital communications network evolving from existing telephone services. The goal of ISDN is to replace the current analog telephone system with totally digital switching and transmission facilities capable of carrying data ranging from voice to computer transmissions, music, and video. ISDN is built on two main types of communications channels: a B channel, which carries data at a rate of 64 Kbps (kilobits per second), and a D channel, which carries control information at either 16 or 64 Kbps. Computers and other devices are connected to ISDN lines through simple, standardized interfaces. When fully implemented (possibly around the turn of the century), ISDN is expected to provide users with faster, more extensive communications services.

Local Area Network (LAN)

A group of computers and other devices dispersed over a relatively limited area and connected by a communications link that enables a device to interact with any other on the network. LANs commonly include microcomputers and shared (often expensive) resources such as laser printers and large hard disks. Most modern LANs can support a wide variety of computers and other devices. Each device must use the proper physical and data-link protocols for the particular LAN, and all devices that want to communicate with each other on the LAN must use the same upper-level communications protocol. Although single LANs are geographically limited (to a department or an office building, for example), separate LANs can be connected to form larger networks. Similar LANs are linked by bridges that act as transfer points between networks; dissimilar LANs are linked by gateways, which both transfer data and convert it according to the protocols used by the receiving network.

The devices on a LAN are known as nodes, and the nodes are connected by cables through which messages are transmitted. Types of cables include twisted-pair wiring, coaxial cable, or fiber-optic (light-transmitting) cable. Nodes on a LAN can be wired together in any of three basic layouts, known as bus, ring, and star. As implied by their names, a bus network is more or less linear, a ring network forms a loop, and a star network radiates from a central hub. To avoid potential collisions when two or more nodes attempt to transmit at the same time, LANs use either contention and collision detection or token passing to regulate traffic.

Mega

Abbreviated M. A prefix meaning 1 million (10^6). In computing, which is based on the binary (base-2) numbering system, mega has a literal value of 1,048,576, which is the power of 2 closest to one million.

Megabit

Abbreviated Mb or Mbit. Usually, 1,048,576 bits; sometimes interpreted as 1 million bits.

Megabyte

Abbreviated MB. Either 1 million bytes or 1,048,576 bytes.

Network Architecture

The underlying structure of a computer network includes hardware, functional layers, interfaces, and protocols (rules) used to establish communications and ensure the reliable transfer of information. Because a computer network is a mixture of hardware and software, network architectures are designed to provide both philosophical and physical

standards for enabling computers and other devices to handle the complexities of establishing communications links and transferring information without conflict. Various network architectures exist, among them the internationally accepted seven-layer open systems interconnection model and International Business Machine (IBM) Systems Network Architecture. Both the open systems interconnection model and the Systems Network Architecture organize network functions in layers, each layer dedicated to a particular aspect of communication or transmission and each requiring protocols that define how functions are carried out. The ultimate objective of these and other network architectures is the creation of communications standards that will enable computers of many kinds to exchange information freely.

Open Architecture

A term used to describe any computer or peripheral device that has published specifications. A published specification lets third parties develop add-on hardware for an open architecture computer or device. The term can also refer to a design that provides for expansion slots that allow the addition of parts to enhance or customize a system.

Open System

In communications, especially in connection with the International Organization for Standardization's Open Systems Interconnection model, a computer network designed to incorporate all devices—regardless of manufacturer or model—that can use the same communications facilities and protocols. In reference to individual pieces of computer hardware or software, an open system is one that can accept add-ons produced by third-party suppliers.

Packet

In general usage, a unit of information transmitted as a whole from one device to another on a network. In packet-switching networks, a packet is defined more specifically as a transmission unit of fixed maximum size that consists of binary digits representing both data and a header containing an identification number, source and destination addresses, and, sometimes, error-control data.

Packet Switching

A message-delivery technique in which small units of information (packets) are relayed through stations in a computer network along the best route currently available between the source and the destination. A

packet-switching network handles information in small units, breaking long messages into multiple packets before routing. Although each packet may travel along a different path, and the packets composing a message may arrive at different times or out of sequence, the receiving computer reassembles the original message. Packet-switching networks are considered to be fast and efficient. To manage the tasks of routing traffic and assembling/disassembling packets, such networks require some "intelligence" from the computers and software that control delivery.

Real-Time System

A computer and/or a software system that reacts to events before the events become obsolete. For example, airline collision avoidance systems must process radar input, detect a possible collision, and warn air traffic controllers or pilots while they still have time to react.

Router

An intermediate device on a communications network that expedites message delivery. On a single network linking many computers through a mesh of possible connections, a router receives transmitted messages and forwards them to the correct destinations over the most efficient available route. On an interconnected set of local area networks using the same communication protocols, a router serves the somewhat different function of acting as a link between networks, enabling messages to be sent from one to another.

Standard

In computing, a set of detailed technical guidelines used as a means of establishing uniformity in an area of hardware or software development. Computer standards have traditionally developed in either of two ways. The first, a highly informal process, occurs when a product or philosophy is developed by a single company and, through success and imitation, becomes so widely used that deviation from the norm causes compatibility problems or limits marketability. This type of de facto standard setting is typified by such products as Hayes modems and IBM Personal Computers. The second type of standard-setting is a far more formal process in which specifications are drafted by a cooperative group or committee after an intensive study of existing methods, approaches, and technological trends and developments. The proposed standards are later ratified by consensus through an accredited organization and are adopted over time as products based on the standards become increasingly prevalent in the market.

Synchronous Operation	Generally, any operation that proceeds under control of a clock or timing mechanism.
TCP/IP	Acronym for Transport Control Protocol/Internet Protocol, a software protocol developed by the Department of Defense for communications between computers and used on the Internet.
Telecommunications	A general term for the electronic transmission of information of any type, including data, television pictures, sound, facsimiles, and so on.
Telecommuting	Also called electronic commuting. The practice of working in one location (often, at home) and communicating with a main office in a different location through a personal computer equipped with a modem and communications software.
Teleconferencing	The use of audio, video, or computer equipment linked through a communications system to enable geographically separated individuals to participate in a meeting or discussion.
Throughput	A measure of the data transfer rate through a typically complex communications system or of the data processing rate in a computer system.
Twisted-Pair Cable	A cable made of two separately insulated strands of wire twisted together.
Virtual Circuit	Literally, a communications link that appears to be a direct connection between sender and receiver, although physically (as on a packet-switching network) the link can involve routing through more circuitous paths. A virtual circuit is conceptual rather than physical. The virtual circuit connects caller A with receiver B, but the physical circuit through which they actually communicate can run from A through stations D, E, and F before reaching B.
Wide Area Network (WAN)	A communications network that connects geographically separated areas.

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